NOVEMBER 1985 / $2.50

annual RECEIVER issue

ham radio magazine

build this compact 75-meter monoband transceiver

hr

focus on communications technology

stable LO's for microwave receivers • 10-80 meter homebrew receiver • adding digital frequency readouts to transceivers • scanner for CB-to-10 meter conversions • external receiver product detector • build a handy RF probe • plus W6MGI, W1JR, W6SAI, W9JUV, and KØRYW

IC-R71A

ICOM HF Receiver

The World Class World Receiver

ICOM introduces the IC-R71A 100KHz to 30MHz superior-grade general coverage HF receiver with innovative features including keyboard frequency entry and wireless remote control (optional).

This easy-to-use and versatile receiver is ideal for anyone wanting to listen in to worldwide communications. With 32 programmable memory channels, SSB/AM/RTTY/CW/FM (opt.), dual VFO's, scanning, selectable AGC and noise blanker, the IC-R71A's versatility is unmatched by any other commercial grade unit in its price range.

Keyboard Entry. ICOM introduces a unique feature to shortwave receivers...direct keyboard entry for simplified operation. Precise frequencies can be easily selected by pushing the digit keys in sequence of frequency. The frequency will be automatically entered without changing the main tuning control.

Superior Receiver Performance. Passband tuning, wide dynamic range (100dB), a deep IF notch filter, adjustable AGC (Automatic Gain Control) and a noise blanker provide easy-to-adjust clear reception even in the presence of strong interference or high noise levels. A preamplifier allows improved reception of weak signals.

32 Tunable Memories. Thirty-two tunable memories, more than any other general coverage receiver on the market, offer instant recall of your favorite frequencies. Each memory stores frequency, VFO and operating mode, and is backed by an internal lithium memory battery.

Options. FM, RC-11 wireless remote controller, synthesized voice frequency readout, IC-CK70 DC adapter for 12 volt operation, MB-12 mobile mounting bracket, two CW filters, FL32-500Hz and FL63-250Hz, and high-grade 455KHz crystal filter, FL44A.

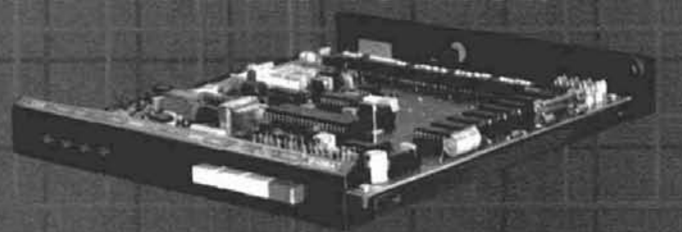
ICOM

First in Communications

ICOM America, Inc., 2380-116th Ave NE, Bellevue, WA 98004 / 3331 Towerwood Drive, Suite 307, Dallas, TX 75234

With SMART PATCH You are in CONTROL

With CES 510SA Simplex Autopatch, there's no waiting for VOX circuits to drop. Simply key your transmitter to take control.



SMART PATCH is all you need to turn your base station into a personal autopatch. SMART PATCH uses the only operating system that gives the mobile complete control. Full break-in capability allows the mobile user to actually interrupt the telephone party. SMART PATCH does not interfere with the normal use of your base station. SMART PATCH works well with any FM transceiver and provides switch selectable tone or rotary dialing, toll restrict, programmable control codes, CW ID and much more.

To Take CONTROL with Smart Patch – Call 800-327-9956 Ext. 101 today.

What To Look For In A Phone Patch

The best way to decide what patch is right for you is to first decide what a patch should do. A patch should:

- Give complete control to the mobile, allowing full break in operation.
- Not interfere with the normal operation of your base station. It should not require you to connect and disconnect cables (or flip switches!) every time you wish to use your radio as a normal base station.
- Not depend on volume or squelch settings of your radio. It should work the same regardless of what you do with these controls.
- You should be able to hear your base station speaker with the patch installed. Remember, you have a base station because there are mobiles. ONE OF THEM MIGHT NEED HELP.
- The patch should have standard features at no extra cost. These should include programmable toll restrict (dip switches), tone or rotary dialing, programmable patch and activity timers, and front panel indicators of channel and patch status.

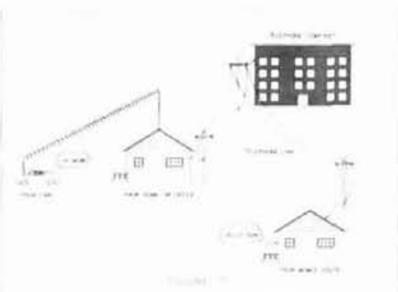
ONLY SMART PATCH HAS ALL OF THE ABOVE.

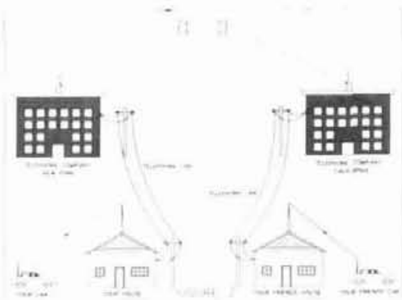
Now Mobile Operators Can Enjoy An Affordable Personal Phone Patch. . .

- Without an expensive repeater.
- Using any FM tranceiver as a base station.
- The secret is a SIMPLEX autopatch. The *SMART PATCH*.

SMART PATCH Is Easy To Install

To install *SMART PATCH*, connect the multicolored computer style ribbon cable to mic audio, receiver discriminator, PTT, and power. A modular phone cord is provided for connection to your phone system. Sound simple? . . . IT IS!





How To Use *SMART PATCH*

Placing a call is simple. Send your access code from your mobile (example: *73). This brings up the Patch and you will hear dial tone transmitted from your base station. Since *SMART PATCH* is checking about once per second to see if you want to dial, all you have to do is key your transmitter, then dial the phone number. You will now hear the phone ring and someone answer. Since the enhanced control system of *SMART PATCH* is constantly checking to see if you wish to talk, you need to simply key your transmitter and then talk. That's right, you simply key your transmitter to interrupt the phone line. The base station automatically stops transmitting after you key your mic. *SMART PATCH* does not require any special tone equipment to control your base station. It samples very high frequency noise present at your receivers discriminator to determine if a mobile is present. No words or syllables are ever lost.

SMART PATCH Is All You Need To Automatically Patch Your Base Station To Your Phone Line.

Use *SMART PATCH* for:

- Mobile (or remote base) to phone line via Simplex base. (see fig 1.)
- Mobile to Mobile via interconnected base stations for extended range. (see fig. 2.)
- Telephone line to mobile (or remote base).
- *SMART PATCH* uses SIMPLEX BASE STATION EQUIPMENT. Use your ordinary base station. *SMART PATCH* does this without interfering with the normal use of your radio.

WARRANTY?

YES, 180 days of warranty protection. You simply can't go wrong.

An FCC type accepted coupler is available for *SMART PATCH*.

Communications Electronics Specialties, Inc.
P.O. Box 2930, Winter Park, Florida 32790
Telephone: (305) 645-0474 **Or call toll-free (800)327-9956**

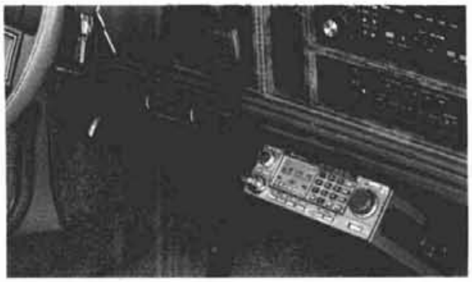
KENWOOD

...pacesetter in Amateur radio

Up Front and Center!

TR-7950/7930

The exceptional front-end selectivity and sensitivity, coupled with Kenwood's excellent audio section, gives you lots to hear! Compact design makes this transceiver at home in the shack or on the go!



- **Large, easy-to-read backlighted LCD readout.**
  Indicates receive/transmit frequency, frequency offset, sub-tone selection, memory status. An LED readout indicates S & RF units, REVERSE, CENTER TUNING, PRIORITY, and ON AIR.
- **Programmable scanning, with center-stop tuning.**
  Microprocessor technology allows you to scan the entire 2 meter band, or just a small portion of it. Scanning stops on the center frequency during band scan—**a Kenwood exclusive!**
- **21 Multi-function memory channels.**
  The TR-7950/7930 "remembers" frequency offset, and optional subtone channels. Memories 1-15 are for simplex and "normal" repeater operation. Memory pairs 16/17 and 18/19 are for "odd-ball" splits. Memories "A" and "B" store upper and lower band scan limits. The radio "beeps" when memory channel 1 is selected.
- **Extended frequency coverage.**
  Covers 142.000-148.995 MHz in 5-kHz steps. Repeater offsets are automatically selected in accordance with the ARRL 2 meter band plan. The front panel "OS" key may be used to allow manual changes in offset.
- **Multi-function keyboard.**
  The 16-key DTMF pad can also be used for direct frequency entry, subtone selection, memory address and scan programming. The keyboard is illuminated for night time use.

TR-7950 optional accessories:

- TU-79 three frequency tone unit
- PS-430 power supply
- KPS-12 fixed-station power supply for the TR-7950
- KPS-7A fixed-station power supply for the TR-7930
- SP-40 mobile speaker
- SP-50 mobile speaker
- MC-55 mobile microphone
- MC-46 16-key autopatch UP/DOWN microphone
- SWT-1 2 m, 100 W antenna tuner
- SW-100A/B power meters
- PG-3A noise filter

Model TR-7950 (45 watts) shown. TR-7930 is identical, but with 25 watts output.

Complete service manuals are available for all Trio-Kenwood transceivers and most accessories.
Specifications and prices are subject to change without notice or obligation.

More TR-7950/7930 information is available from authorized Kenwood dealers.

KENWOOD

TRIO-KENWOOD COMMUNICATIONS
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Compton, California 90220

ham radio magazine

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contents

MFJ TUNERS

This may be the world's most popular 3 KW roller inductor tuner because it's small, compact, reliable, matches virtually everything and gives you SWR/Wattmeter, antenna switch, dummy load and balun — all at a great price!

Meet "Versa Tuner V". It has all the features you asked for, including the new smaller size to match new smaller rigs-only 10¾"Wx4½"Hx14 7/8"D.

Matches coax, balanced lines, random wires—1.8 to 30 MHz. 3 KW PEP —the power rating you won't outgrow (250pf-6KV caps).

Roller inductor with a 3-digit turns counter plus a spinner knob for precise inductance control to get that SWR down to minimum every time.

Built-in 300 watt, 50 ohm dummy load, built-in 4:1 ferrite balun.

MFJ-989 **$329.95**

Accurate meter reads SWR plus forward and reflected power in 2 ranges (200 and 2000 watts). Meter light requires 12 VDC. Optional AC adapter, MFJ-1312 is available for $9.95.

6 position antenna switch (2 coax lines, through tuner or direct, random/balanced line or dummy load). SO-239 connectors, ceramic feed-throughs, binding post grounds.

Deluxe aluminum low-profile cabinet with sub-chassis for RFI protection, black finish, black front panel with raised letters, tilt bail.

MFJ's Fastest Selling TUNER

MFJ-941D **$99.95**

MFJ's fastest selling tuner packs in plenty of new features. New styling! Brushed aluminum front. All metal cabinet. **New SWR/Wattmeter!** More accurate. Switch selectable 300/30 watt ranges. Read forward/reflected power.

New antenna switch! Front panel mounted. Select 2 coax lines, direct or through tuner, random wire/balanced line or tuner bypass for dummy load.

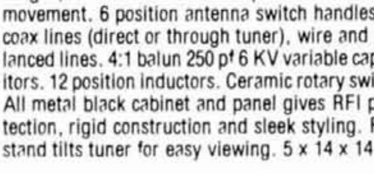
New airwound inductor! Larger more efficient 12 position airwound inductor gives lower losses and more watts out. Run up to 300 RF power output.

Matches everything from 2.8 to 30 MHz! dipoles, inverted vee, random wires, verticals, mobile whips, beams, balanced and coax lines.

Built-in 4:2 balun for balanced lines. 1000 V capacitor spacing. Black. 11 x 3 x 7 inches. Works with all solid state or tube rigs. Easy to use anywhere.

MFJ's 1.5 KW VERSA TUNER III

MFJ-962 **$229.95**



Run up to 1.5 KW PEP and match any feedline continuously from 1.8 to 30 MHz: coax, balanced line or random wire.

Built-in SWR/Wattmeter has 2000 and 200 watt ranges, forward and reflected power. 2% meter movement. 6 position antenna switch handles 2 coax lines (direct or through tuner), wire and balanced lines. 4:1 balun 250 pf 6 KV variable capacitors. 12 position inductors. Ceramic rotary switch. All metal black cabinet and panel gives RFI protection, rigid construction and sleek styling. Flip stand tilts tuner for easy viewing. 5 x 14 x 14 in.

MFJ's Best VERSA TUNER

MFJ-949C **$149.95**

MFJ's best 300 watt tuner is now even better! The MFJ-949C all-in-one Deluxe Versa Tuner II gives you a tuner, cross-needle SWR/Wattmeter, dummy load, antenna switch and balun in a new compact cabinet. You get quality conveniences and a clutter-free shack at a super price.

A new cross-needle SWR/Wattmeter gives you SWR, forward and reflected power—all at a single glance. SWR is automatically computed with no controls to set. Has 30 and 300 watt scale on easy-to-read 2 color lighted meter (needs 12 V).

A handsome new black brushed aluminum cabinet matches all the new rigs. Its compact size (10 x 3 x 7 inches) takes only a little room.

You can run full transceiver power output—up to 300 watts RF output—and match coax, balanced lines or random wires from 1.8 thru 30 MHz. Use it to tune out SWR on dipoles, vees, long wires, verticals, whips, beams and quads.

A 300 watt 50 ohm dummy load gives you quick tune ups and a versatile six position antenna switch lets you select 2 coax lines (direct or thru tuner), random wire or balanced line and dummy load.

A large efficient airwound inductor—3 inches in diameter—gives you plenty of matching range and less losses for more watts out. 100 volt tuning capacitors and heavy duty switches gives you safe arc-free operation. A 4:1 balun is built-in to match balanced lines.

Order your convenience package now and enjoy.

2 KW COAX SWITCHES

MFJ-1702 **$19.95**

MFJ-1702, $19.95. 2 positions. 60 dB isolation at 450 MHz. Less than .2 dB loss. SWR below 1:1.2.

$29.95 MFJ-1701

MFJ-1701, $29.95. 6 positions. White markable surface for antenna positions.

MFJ's Smallest VERSA TUNER

MFJ-901B **$59.95**

MFJ's smallest 200 watt Versa Tuner matches coax, random wires and balanced lines continuously from 1.8 thru 30 MHz. Works with all solid state and tube rigs. Very popular for use between transceiver and final amplifier for proper matching. Efficient airwound inductor gives more watts out. 4:1 balun for balanced lines. 5 x 2 x 6 inches. Rugged black all aluminum cabinet.

MFJ's Random Wire TUNER

MFJ-16010 **$39.95**

MFJ's ultra compact 200 watt random wire tuner lets you operate all bands anywhere with any transceiver using a random wire. Great for apartment, motel, camping operation. Tunes 1.8-30 MHz. 2 x 3 x 4 inches.

MFJ's Mobile TUNER

MFJ-945C **$79.95**

Designed for mobile operation! Small, compact. Takes just a tiny bit of room in your car. SWR/dual range wattmeter makes tuning fast and easy. Careful placement of controls and meter makes antenna tuning safer while in motion.

Extends your antenna bandwidth so you can operate anywhere in a band with low SWR. **No need to go outside and readjust your mobile whip.** Low SWR also gives you maximum power out of your solid state rig—runs cooler for longer life.

Handles up to 300 watts PEP RF output. Has efficient airwound inductor, 1000 volt capacitor spacing and rugged aluminum cabinet. 8x2x6 inches. Mobile mounting bracket available for $5.00.

ORDER ANY PRODUCT FROM MFJ AND TRY IT-NO OBLIGATION. IF NOT SATISFIED, RETURN WITHIN 30 DAYS FOR PROMPT REFUND (less shipping).
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muchas gracias

Yesterday, September 20, a massive earthquake struck Mexico City. Early reports from the networks and wire services told of massive damage in Mexico City, with 25 per cent of the downtown area totally destroyed, and thousands of deaths and injuries. Ships have been reported missing and a tsunami wave has severely damaged part of the Mexican coastline. All modes of communications — save one — are down and authorities have no idea of when service might be restored.

The one mode that's still functioning is Amateur Radio. I've spent quite a while listening to the emergency traffic being passed on a number of frequencies; I'm quite impressed with how effectively and efficiently health and welfare traffic is being passed. But there's a personal sense of urgency to my listening this time: my youngest brother is in Mexico City, and my family and I have no way of knowing if he's all right.

Yes, the State Department has a hotline that we can call for information. But the volume of calls received has shut the system down. We've contacted the Red Cross, but they're too busy passing more important medical traffic.

So how do I — or others — use Amateur Radio to find out about the safety of relatives and friends? I'm afraid I really don't know. I usually have the world at my fingertips with just the flip of a switch and the twist of a dial. But right now I feel just about totally helpless in trying to get the information I want.

Propagation into the Mexico City area isn't favorable at this time, and I'm reluctant to jump into a pile-up and add to the confusion. But that's about the only way I'll be able to get a message to the Mexican stations. . . .

There's got to be a better way! Would somebody please tell me what it is?

Craig Clark, N1ACH
Assistant Publisher

Craig's inital feeling of helplessness is completely understandable. The circumstances — a natural disaster that, within 60 seconds, killed thousands, injured many, and caused catastrophic damage to buildings and other structures — is something one doesn't deal with on a daily basis. So it's hard to pull from your experience and function immediately.

Several things are reasonably certain: all conventional power and most telephone service is gone. Few reliable means of communicating with the outside world are available. This is where Radio Amateurs come in — and what a service they provide! Just after the Mexico City earthquake, several stations were on the air. One in particular that I heard was XE1VIC, manned by Vic and Sergio, who did a yeoman's job in passing health and welfare information, medical emergency traffic, and high-level government phone patches.*

With this in mind, what can *you* do to find out about the safety of a relative or friend known to be in a particular area when disaster strikes?

LISTEN CAREFULLY. If there's any activity from the devastated area, someone as competent as XE1VIC is likely to be on the air. If you don't hear such a station, continue listening. Chances are good that other Amateurs, in your country will have information and be discussing it.

IF YOU DON'T HEAR, ASK. Once again, someone will probably know something.

THINK. For the distances involved, time of day, and propagation, one particular band will be optimum. Try it. XE1VIC was 59+ into New Hampshire on 80 meters for hours.

LISTEN FOR INSTRUCTIONS. The control station will make it very clear as to how he wishes to proceed. Many stations will be attempting to contact him. Though it may seem like contest operation at times, remember that a disaster has occurred, and discipline is essential.

BE BRIEF. Once you've gotten the traffic handler's attention, give the information required — nothing more, nothing less. Decide beforehand how you might be able to help.

ACCEPT THE RESPONSE GIVEN. Once he contacted the requested relative or friend, XE1VIC kept his side of the conversation short and sweet. Most of the time the news was very good, and in every case he was extremely reassuring. Remember that many other stations are concerned about their loved ones, too.

OTHERS WILL HELP PASS YOUR MESSAGE. In this case, stations in the Houston area acted in this capacity.

Every emergency, of course, is different. These are just a few suggestions that have been applied in the past and appear to work.

Rich Rosen, K2RR
Editor-in-Chief

Note: Craig's brother returned home safely on September 23.

*XE1VIC was just one of many Mexican stations that should be commended. In addition, the list of U.S. and international stations that contributed to the success of this traffic handling situation in a calm and controlled manner is long, and one we should be quite proud of — proving once again how Radio Amateurs rise to the occasion and provide a real service.

presstop de W9JUV

AMATEUR RADIO'S RESPONSE FOLLOWING MEXICO CITY'S DISASTROUS EARTHQUAKE was, in short, simply overwhelming! Almost before the first major tremors ended, a number of Mexico City stations were on and handling emergency traffic with the U.S. As the hours wore on and the disaster's magnitude became apparent, the activity multiplied—but even after health and welfare input began, and despite a variety of message handling techniques, turnaround was generally quite fast. W9JUV's first two Friday afternoon inquiries came back "We're all OK!" from XE1USA in under five minutes! Amateur Radio's media exposure was also fantastic due to the complete breakdown in commercial communications, which left the Amateur Service as the media's only source of earthquake news for a number of hours.

Media Abuse Of Amateur Radio Was Also Extensive, unfortunately. Not only was there the usual "XE1XX, I have Newt Newshawk of NNUT-TV in the shack to ask you some questions," but all of the networks and news services invaded the Amateur bands for their coordination and logistical efforts! Heard on 20 meters Sunday were equipment requests, personnel assignments, even arguments about overtime and the special menu needs of a network anchor! To its credit, NBC's Mexico City station did take health and welfare traffic and made phone calls when not otherwise occupied; inquiries to the others triggered responses that they were too busy on network business to make casual contacts! The FCC is very much interested in this media incursion, and would appreciate receiving specific reports and tapes on it.

One Glaring Weakness Of Amateur Radio Was Quickly Apparent—anxious friends and relatives of persons living in or visiting Mexico City had no idea of how to locate hams willing to relay messages. Though churches, community centers, the Red Cross, and even some Amateur Radio dealers were often able to make referrals, what's badly needed—before another such catastrophe strikes—is a well advertised, accessible conduit through which the public can reach Amateur Radio operators able to communicate with loved ones abroad.

Despite Such Problems, However, Amateur Radio Has Never Served People Better or made a deeper, more favorable impression on the public than it has during Mexico City's agony. "Well done!" to all involved, both those actively participating and the many "stand-bys."

STATE AND LOCAL REGULATIONS MAY NOT PRECLUDE AMATEUR COMMUNICATIONS, the FCC declared in its September 16 decision on PRB-1! Responding to the ARRL's July, 1984, request for a Declaratory Ruling limiting local limitations on Amateur operations and stations, the FCC affirmed "a strong federal interest in promoting Amateur communications" and cited Amateur Radio's value in "providing emergency communications" and "a reservoir of trained operators, technicians and electronic experts," as well as furthering international goodwill. In summary, they said: "State and local regulations that operate to preclude Amateur communications in their communities are in direct conflict with federal objectives and must be preempted."

Though They Did Not Specify Any Minimum Antenna Height, the Commission further stated, "...local regulations which involve placement, screening, or height of antennas based on health, safety, or aesthetic considerations...must be crafted to accommodate reasonably Amateur communications (with) minimum practicable regulation...."

Though The Lack Of A Specified Height Will Cause Some Amateurs Problems, the FCC's action is certainly going to help the vast majority. Also not covered are Amateurs who've signed restrictive covenants, since those are private contracts entered into voluntarily.

Congratulations To The Commissioners And FCC Staff for a courageous decision, since their favorable ruling for Amateur antennas and operations will undoubtedly be cited by other services who'd also like to get out from under the yoke of local regulation.

POSSIBLE FEDERAL SANCTIONS AGAINST "ELECTRONIC EAVESDROPPING" are close to being introduced in the U.S. House of Representatives by Rep. Kastenmeyer. In his "Electronic Communications Privacy Act of 1985," Rep. Kastenmeyer proposes restricting the monitoring of any transmission by "wire, radio, electromagnetic, or photoelectric system..." with exceptions for communications "readily accessible to the public," stations for general public use, distress signals, police or fire, and Amateur or CB stations. Penalties for commercial violators could be $25,000 and a year in prison, others $5,000 and six months.

Though The Goal Is Almost Surely The Protection Of Cellular Radio, the effect on Amateurs and others with a general interest in radio communications could be serious.

APPLICANTS WHO FLUNK AN AMATEUR EXAM NEEDN'T WAIT 30 DAYS to retake the exam, the FCC decided September 16. In its decision to eliminate the waiting period entirely, the Commission agreed a delay had little benefit and dropping it could permit applicants who failed the first day of a two-day hamfest to review problem areas for a second-day try.

DPØSL WILL BE THE CALLSIGN FOR THE UPCOMING EUROPEAN STAFFED SPACEFLIGHT, now set for launch about October 30th on Space Shuttle Flight 61-A. They will listen on 437.125, 437.175, 437.225, 437.275, 437.325, and 437.375 MHz; transmit on 145.450, 145.475, 145,550, or 145.575 MHz. 145.575 down, 437.275 MHz up will be the normal pair.

Rumors Of 10 Or 15-Meter Operation Still Persist at presstime; an operating schedule for DPØSL has not yet been released.

You may not be able to solve the world's problems. But at least you can listen.

The Panasonic Command Series™ With double superheterodyne tuning, you'll hear the world loud and clear.

Now it's easy to listen in on the world's hot spots. With the Panasonic RF-B600 Command Series FM/LW/MW/SW receiver.

Its advanced microcomputer-controlled tuner lets you preset up to nine different frequencies. And reach them at the touch of a button. Or, press the appropriate buttons and tune in any desired frequency with direct-access digital tuning. It'll lock right in to every signal with a PLL quartz-synthesized tuner. Once tuned in, the Panasonic double superheterodyne system helps deliver a clean, consistent signal.

There's even built-in auto-tuning to let you scan the shortwave band automatically, as well as manually. All this means you can tune in Berlin, pick up Paris, or locate London in an instant. Without dialing all over the band.

Both the RF-B600 and the RF-B300 are packed with features and built to go anywhere.

The Panasonic Command Series offers something for everyone. With equipment sophisticated enough to impress the most avid enthusiast, and automatic features that get you where you want to be. Fast.

There's a whole world out there that's waiting to be heard. Tune in to it with the Panasonic Command Series.

Batteries not included.

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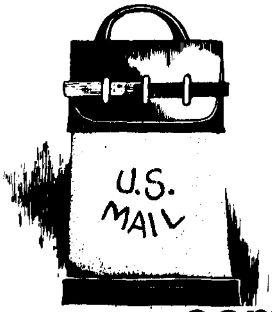
just slightly ahead of our time.™



comments

practically speaking

Dear HR:

Joe Carr, K4IPV, is off to a fair start with his new column, "Practically Speaking." The first (September, page 67) was good reading. I have to disagree with him, however, when he says, "The first time to think about repairs is while you're unpacking the new rig."

Wrong.

The first time to think about repairs is *before* the rig is bought. The unpacking stage is too late.

Before plunking down several kilobucks for one of the so-called state-of-the-art transceivers being marketed these days, ham operators need to give serious, careful thought to the crucial question of servicing and maintaining the rig(s) under consideration. Is that aspect of ownership going to cost an arm, a leg and another part of the anatomy — to say nothing of the time spent without the rig while it is being repaired?

Are all those gongs, whistles, and bells *really* worth it? Does one truly need rigs that scan, memorize, and do all sorts of other gimmicks?

Two years ago two friends here returned from a national Amateur Radio convention, each with a new rig. One, who purchased the latest offering from Brand X had to return the rig to the factory once while it was still under warranty and twice since then. He is no slouch at troubleshooting or repair, but the complicated circuitry was more than he could handle. Labor, parts, and shipping charges thus far have totaled more than one-third the original cost of the transceiver, and he has been without it almost 60 days altogether.

My second friend brought home a shiny, new Brand Z transceiver. It was almost a pure vanilla rig with no gong, whistles, or bells. It has sat in his shack and has worked, day in and day out. What few repairs have been needed were done quickly, easily and inexpensively. He said he decided on that rig because of the ease and simplicity of operation.

Practically speaking, which do you think was the more practical?

Fred Conavita, W5QJM
Austin, Texas

audio filter design

Dear HR:

Instead of transforming the normalized values of a five-branch Butterworth low-pass prototype design to get a five-branch high-pass as discussed in Stefan Niewiadomski's article, "Passive Audio Filter Design," part 2, October, 1985, a simpler procedure would be to use standard-value capacitor (SVC) filter tables to select an appropriate design. The fact that the SVC capacitor design values are exactly identical to the commercially available standard values simplifies construction. For example, a "near-Butterworth" 500-ohm design with a VSWR of 1.023 and a 3-dB cutoff frequency of 487 Hz (within 3 percent of the desired 500 Hz cutoff frequency) is available with standard values of C1,5 = 0.82 μF and C3 = 0.33 μF. L2,4 = *96.2 mH.* The 20-dB and 40-dB attenuation frequencies are 330 and 214 Hz. Some SVC filter tables appear in *The ARRL 1985 Handbook, (pages 2-40 through 2-44)* and a more complete selection will appear in the next edition of the *Radio Handbook*, edited by Bill Orr, and to be published soon by Howard W. Sams and Co., Inc. The SVC filter tables were also published in the record of the IEEE 1985 International Symposium on Electromagnetic Compatibility held in Wakefield, Massachusetts from August 20-22. *ham radio* readers should therefore understand that the preferred procedure for designing simple passive LC filters, such as generally required by the Radio Amateur, is to use SVC filter tables. The procedure explained by Niewiadomski should be used only when there is a special requirement for a specific response type and a precise cutoff frequency.

Ed Wetherhold, W3NQN
Annapolis, Maryland

J-pole or Zepp?

Dear HR:

K1WWT is right, (see "J-pole or Zepp," Comments, *ham radio*, February, 1985, page 8). The J-pole antenna described in KD8JB's earlier *ham radio* article* is a Zepp antenna.

The Zepp antenna, named for the Zeppelin airship, on which it was originally used, is not a 3/4-wave antenna operating against a 1/4-wave counterpoise as KD8JB mentioned in the reply comments.

The classical Zepp antenna, now more than 75 years old, is a full-wave current-fed antenna with a 1/4-wave section folded over on itself. This leads to a 1/2-wave end-fed radiator with 1/4-wave matching transformer. The antenna at first was a balloon antenna (**fig. 1**) and looked like an inverted J-pole dangling from the airship. In the beginning the matching transformer and the radiator hung in a straight line. Later on the matching transformer was set at right angles to the radiator. This low-voltage input feed arrangement was a remarkable improvement over the dangerous practice of using a high-voltage feed in the presence of the oxyhydrogen-gas with which the balloons were filled.

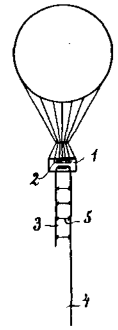


fig. 1. The Zepp antenna, designed by Dr. Hans Beggerow, was patented in Germany in 1909. The illustration above accompanied the original patent.

Alois Krischke, DJ0TR/OE8AK
Munich, West Germany

*See "All-metal, 2-meter J-pole Antenna," *ham radio*, July, 1984, page 42.

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THE INTELLIGENT SATELLITE TELEVISION SYSTEM

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Where all the satellites are

Up to 36 satellite locations can be programmed for instant recall. The antenna controller is integrated into the satellite receiver. The hand-held remote control activates a 3-speed actuator action which precisely locates the satellite and fine tunes the antenna position for maximum signal reception.

Where all the channels are

Every channel on every satellite is individually factory programmed prior to delivery. All audio and video information is ready for recall automatically. As new channels are added they can be added to the program. The 9900 is ready to receive individual channel selection information for up to 864 separate selections.

All about stereo Hi-Fi sound

5 audio modes, factory programmed to individual transponders, deliver the right sound system automatically when a channel is selected. Dozens of audio subcarriers can be added to the program for audio only hi-fi enjoyment (including Dolby® Noise Reduction) in addition to television.

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The front panel LED display tells you what satellite you're on, what channel you're watching, what sound system you're receiving and a signal bar graph indicates signal strength. All functions are controlled from the hand-held wireless remote.

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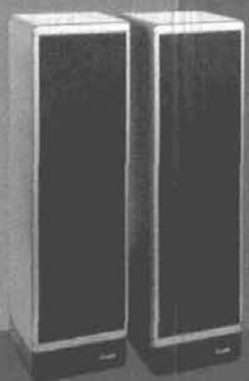
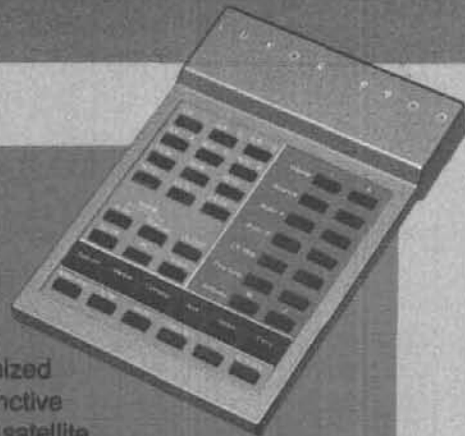
Luxor loudspeakers bring new life to TV audio, mono or stereo, and much more. Satellite audio sub-carriers broadcast a wide range of music for audio only. These optional high quality 6-speaker sets (3 per side) are available in passive or active models with sound power up to 40 W per channel. They are specially magnetic shielded for close location to your TV set.



Simple, clear and color-coded



The Luxor hand-held remote is clearly organized to make life easy. Distinctive color sections present satellite and channel selection functions, tuning functions and switching functions. For most viewing however, video and audio delivery will be automatic. When a channel is selected, the exclusive Luxor Micro-Step™ Tuning System (LMS) automatically seeks out the right signal within that channel's frequency. The receiver automatically compensates for any form of frequency drift due to climate or transponder variances.

An internal TI filter can be assigned to individual channels to minimize terrestrial interference.

And a discrete parental lock-out can eliminate one or more individual channels on a single satellite, as desired.

That's it. Advanced Luxor technology has produced a system so simple to operate, yet complete enough to satisfy the most fanatic videophile and audiophile. For the technician, the Luxor 9900 even has its own diagnostic system built-in and ready at the touch of a button.

Here is the best of Scandanavian design and high technology. Because Luxor is a leading European manufacturer of satellite products, TV's, audio hi-fi systems, and computers, the company is able to combine these technologies in the advanced 9900 series. After all, Luxor has been a leader in radio, television and electronic technology since 1923.

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The Luxor Model 9995 Block Satellite Receiver is designed and built to function as an add-on receiver to Luxor 9900 multiple TV's installations. This low cost manually operated receiver offers independent channel selection for TV's located throughout the house. The 9995 can also be used as a stand-alone receiver for both C-Band and Ku-Band reception.

LUXOR HAS ADVANCED THE STATE-OF-THE-ART TO THE POINT OF ELEGANT SIMPLICITY FOR THE CONSUMER AND THE TECHNICIAN

Each electronic innovation is incorporated to aid ease of operation, assure high performance reliability, and maintain outstanding quality of both picture and sound.

9900 Block Receiver

Control Functions

+ Integrated satellite receiver and antenna controller.
• C-band (4 GHz) and Ku-band (12 GHz) capable. Remote control switchable.
• Satellite direct access.
• Transponder direct access.
+ Built-in A/B switch.
+ "Normal" button return to factory pre-set values.
• Built-in polarotor drive.
• Built-in RF modulator.
• Non-volatile memory unaffected by power outages.
• Remote sensor interface.

Programs

+ Factory programmed for individual transponders on each satellite.
+ Automatic correct audio system factory programmed for each satellite and each transponder.
+ Program capacity up to 864 individual selections, audio video matched and fine tuned.
+ Self-diagnostic microprocessor.
+ LED display of satellite, channel, audio system and signal strength

Video Functions

+ Luxor Micro-Step™ tuning system (LMS).
• Baseband audio and video output for VCR or monitor.
+ Baseband input for other video sources.
• Built-in polarity control.
+ Built-in programmable TI filter.
• Raw video (unfiltered, unclamped) for descrambler connection.

Audio Functions

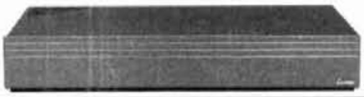
+ Audio subcarrier frequency read-out.
• Wide/Narrow Bandwidth selection.
+ Remote audio volume control.
+ Remote stereo balance control.
+ Remote Dolby® on/off
+ 5 audio modes–2 mono, 2 matrix, and discrete stereo. Automatic multiplex selection.
• Built-in stereo processor.
+ Direct loudspeaker drive.

9902 Remote Sensor

• Controls satellite system from any room.
• Low-cost add-on for other TV's.
• Comes complete with hand-held IR remote control.

9901 Remote Control

+ Full-function, color-coded IR wireless remote control.
+ Remote ON/OFF
+ Discrete parental lock-out for individual channels.
+ Remote mute.
+ Volume control.
+ Stereo balance.
• Channel UP/Down.
+ Video fine tune.
+ Audio fine tune
• Antenna fine tune.
• Satellite selection.
• Channel selection.
+ Divided into 4 easy-to-read segments: Satellite selection, channel selection, tuning functions, switching functions.



9904 Actuator Interface

+ 36V power supply to antenna drive.
+ Surge protected.
+ Voltage spikes protected.
+ Design coordinated with 9900.
+ Can be wall-mounted out of sight.

9906/9907 Stereo Loudspeakers

+ Passive or active models.
+ Up to 40 W per channel.
+ 3 elements per side; tweeter, mid-range and woofer.
+ Magnetic shielded.
+ Automatic ON/OFF.
+ LED indicators; standby and active.
+ Complete with line cable feed.

9995 Block Satellite Receiver

+ Add-on "slave" to 9900 multiple TV's installations.
+ Can function as a stand-alone block receiver; C-band and Ku-band reception.
+ Manually operated channel selection.
+ Video fine tune. AFC defeat.
+ Built-in V/H switch.
+ Built-in antenna switch for satellite or local reception.
+ Preprogrammed audio frequencies 6.2 and 6.8 MHz.
+ Audio frequency selection 5.0 to 8.0 MHz.
+ Wide/narrow audio bandwidth selection.
+ Raw video output (unclamped, unfiltered) for descrambler connection.
+ External TI filter input.
+ Skew control.
+ Polarotor One control output.

+ Denotes new features available only on 9900 series products.

Luxor High-Performance Microwave Block Downconverters

Designed and constructed for continuous reliable performance, each Luxor unit is individually inspected and tested against all specification requirements. The Block Downconverter (30 dB gain min.) is used in conjunction with an LNA. The LNB Block Downconverter (60 dB gain min.) is an LNA and a Block Downconverter in one compact package. Each unit is weather-tight, rust-proof and fully warranted.

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✓ 106

a compact 75-meter monoband transceiver

Modular design yields 30 watts PEP *and* high performance

This article describes a compact monoband SSB transceiver that employs broadband techniques, IC building blocks, and an FET power chain. A detailed block diagram that shows all module interconnections is shown in **fig. 1**. As an extension of an earlier receiver project, the design provides all of the basic features required for convenient operation.[1] The receiver section offers excellent sensitivity and selectivity, audio-derived AGC, an S-meter, headphone or speaker operation, and above-average audio quality. The transmitter has amplified ALC and delivers 30 watts PEP to a 50-ohm load. The completed package is about the size of a 2-meter FM transceiver, measuring 2 × 5 × 6 inches (5 × 12.7 × 15.25 cm) and weighing about 2 pounds (1 kg).

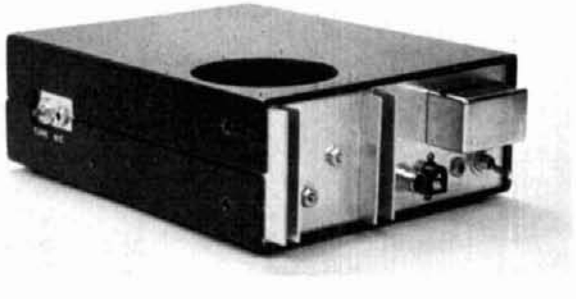
circuit description

The transceiver employs a single conversion frequency plan with a 9-MHz IF and a 5.0-MHz VFO. Receiver preselection is provided by a two-section bandpass filter (see **fig. 2**). Additional HF rejection is obtained from the transmitter's low-pass filter. Receiver mixer U1 is an active DBM which has been biased for maximum gain. Mixer output is fed to crystal sideband filter FL1 through a simple diode switching network.

IF stage U2, shared by the transmitter, provides 45 dB of gain with an AGC range of about 70 dB. Gain for the entire receiver is controlled via U2's AGC line. Automatic control is audio-derived from the output of audio amplifier U4. Manual control is provided by a voltage divider circuit. During the receive cycle, the two control voltages are gated onto the AGC line through diodes. The output of IF amplifier U2 is simultaneously fed to product detector U3 and transmit mixer U7. U3, an active DBM product detector, provides audio detection and additional system gain.

Since gain is controlled exclusively through IF amplifier U2, audio amplifier U4 operates at full gain (see **fig. 3**). U4 provides 400 mW of output — more than enough to drive the transceiver's small built-in speaker. Attenuation is provided for speaker protection and for headphone operation.

AGC voltage is sampled from the output of U4, detected, and fed to DC amplifier Q1. The RC time constant of Q1 is switched to provide slow release time during receive, and fast release time during transmit. Q2 provides additional amplification of the control signal, sets the AGC threshold for U2, and drives meter M1. M1 functions as an S-meter during receive and as an ALC indicator during transmit. The entire receiver section operates from a 12-volt source with an average current drain of only 50 mA on receive.



A small heatsink is sufficient for intermittent SSB operation, but area should be increased for CW operation. Mounting FL1 on rear panel saves internal space.

By Rick Littlefield, K1BQT, Box 114 Barrington, New Hampshire 03825

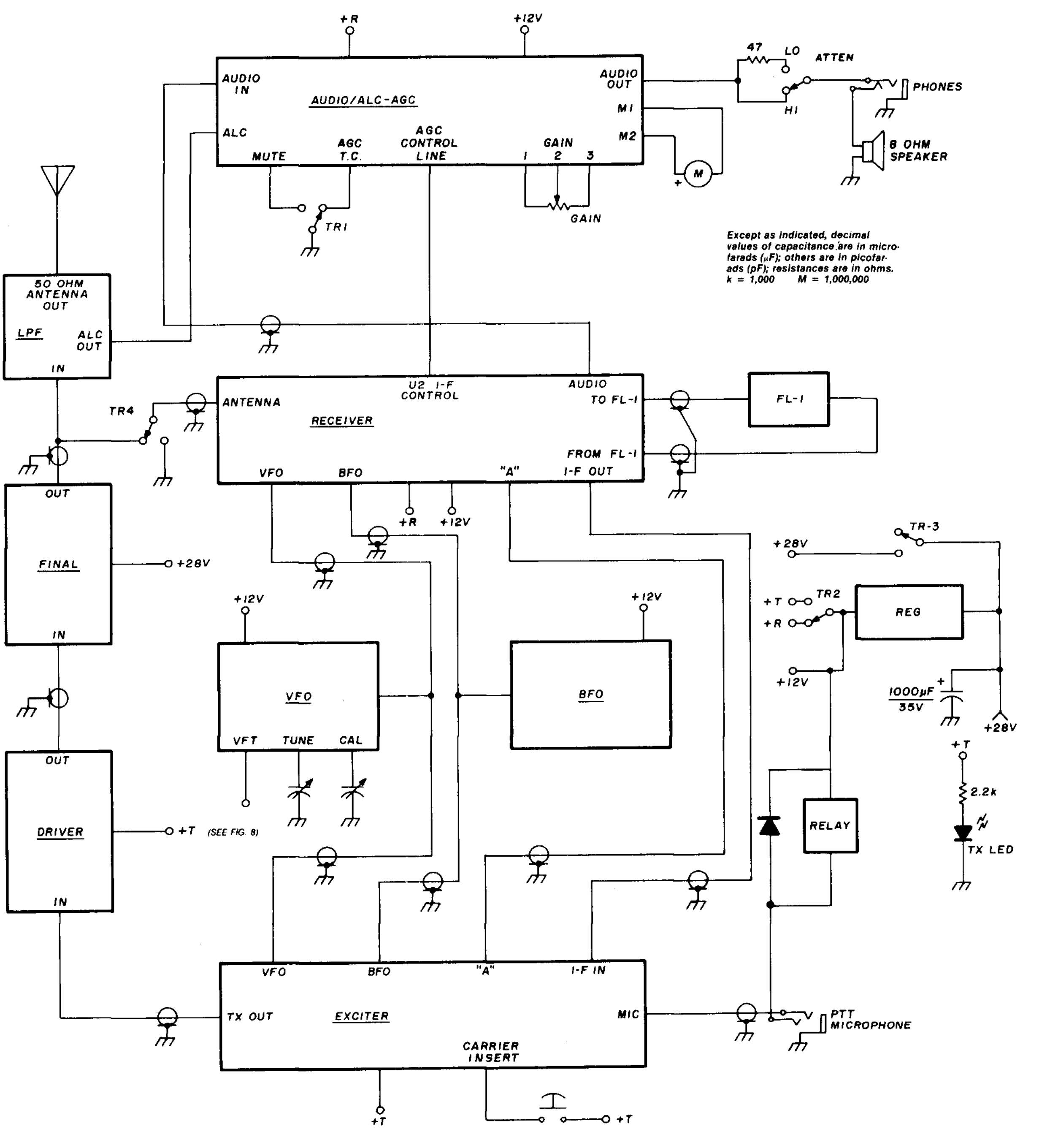
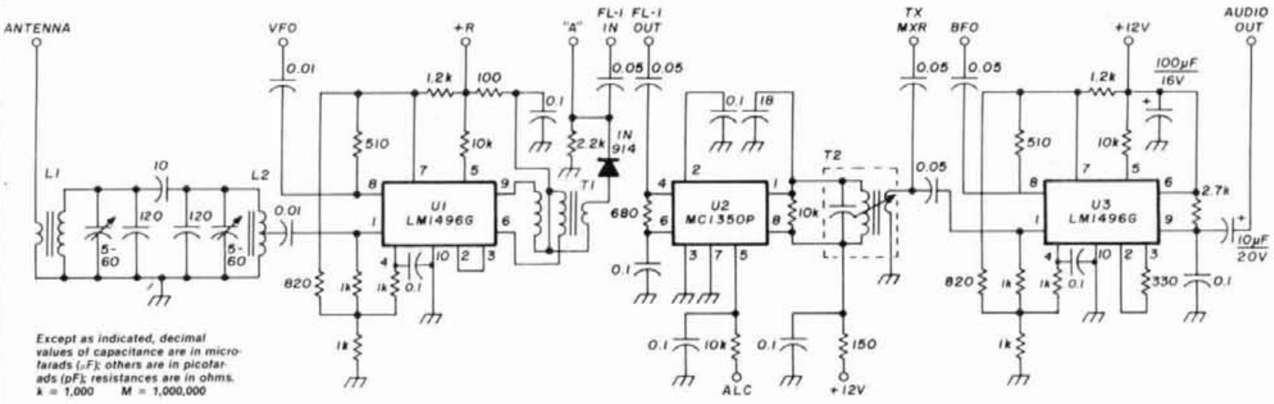


fig. 1. Module interconnections

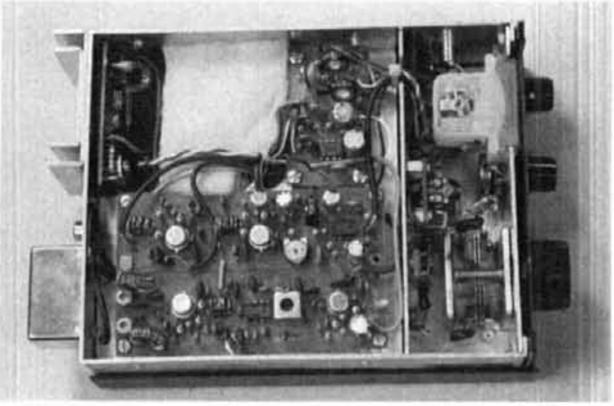
Low-Z microphone amplifier U5 is a standard op-amp circuit which develops the necessary audio voltage to drive balanced modulator U6 (see **fig. 4**). Like all other mixing devices in the transceiver, U6 is an active DBM. Provisions are made to unbalance the device when carrier is needed for RF chain or antenna tuner adjustment. The output of U6 is fed through a diode switching network to sideband filter FL1 and IF amplifier U2. As noted earlier, ALC voltage is applied to U2 during transmit to maintain high transmitter output without driving the RF chain into saturation.

Transmit mixer U7 combines the IF signal from U2 with VFO drive to produce 75 meter output (a CW-only design would substitute BFO drive for the IF signal). The output of U7 is buffered and amplified by



L1 38 turns on T50-2, 3 turn link
L2 38 turns on T50-2, tap at 18 turns
T1 9 turns No. 28 × 3 on FT37-43
T2 10.7 MHz transformer (morning distributors)
U1,U3 LM-1496G
U2 MC1350P

fig. 2. Receiver module. All phasing and combining of transformer leads is done via the circuit board layout. Transformer leads are simply inserted as shown.



Receiver, exciter, and audio modules are located in the top compartment of the cabinet. VFO is in a separate front compartment.

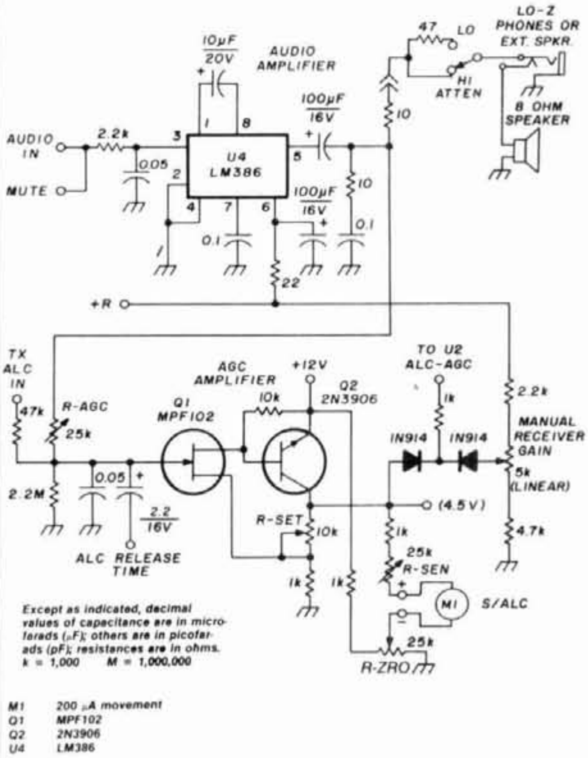


fig. 3. Audio amplifier/ALC-AGC.

pre-driver Q3 (see **fig. 5**). If CW operation is anticipated, keying can be added to this stage by simple modification. Output can be reduced for QRP operation by adjusting the bias on gate No. 2. The output of Q3 is filtered by a two-section bandpass filter. Driver Q4, an inexpensive HEXFET, develops 300 mW PEP — enough power to drive PA Q5. A three-element low-pass filter reduces harmonic content prior to final amplification

The final amplifier Q5 is a Motorola T-MOSFET operating in class AB (see **fig. 6**). At 4 MHz, this 28-volt device operates at approximately 70 percent efficiency, provides 20 dB of gain, and delivers 30 watts PEP into a 50-ohm load. The output of Q5 is transformed to 50 ohms through 4:1 balun T5 and fed into a 7-element Chebyshev low-pass filter. A diode detector at the LPF input samples amplifier output for ALC (see **fig. 7**).

All transmit and receive mixing functions are handled by active DBMs, devices which require no more

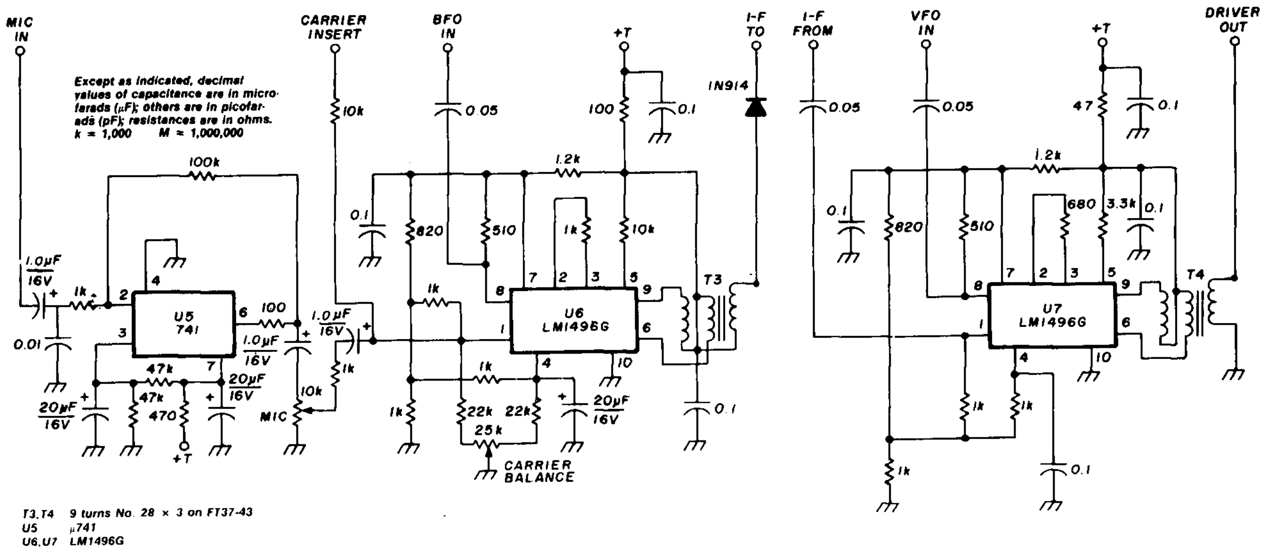


fig. 4. Exciter module.

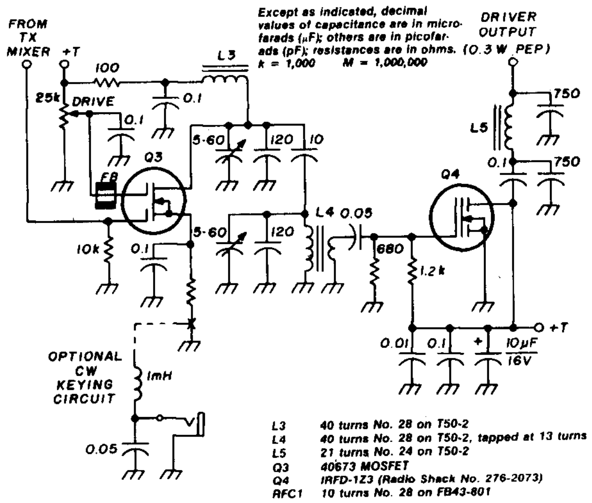


fig. 5. Driver/BPF module.

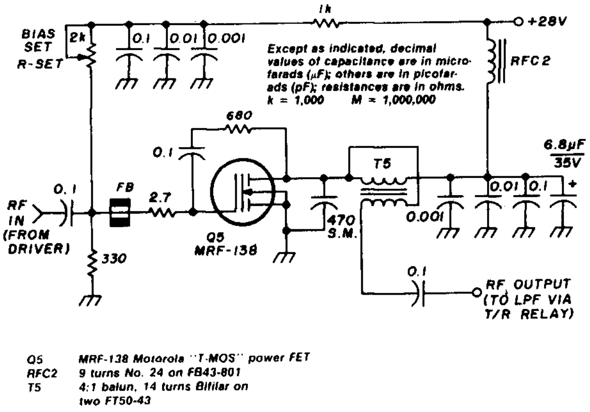


fig. 6. Final amplifier module.

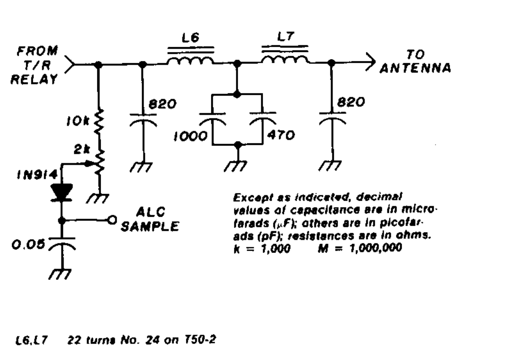


fig. 7. LPF/ALC detector module.

than 100 mV of injection. Consequently, drive demands on the VFO and BFO are minimal. VFO Q6 is a popular Hartley JFET circuit which is buffered by source follower Q7 (see **fig. 8**). An optional VFT control aids fine tuning. BFO Q8 is a simple unbuffered crystal oscillator (see **fig. 9**). If the transceiver is modified for 20 or 15-meter operation, the BFO output should be carefully matched to its load and filtered for harmonic content.

The PA is the only stage requiring a 28-volt source. An on-board monolithic voltage regulator reduces supply voltage to the other stages. The compact 28-volt

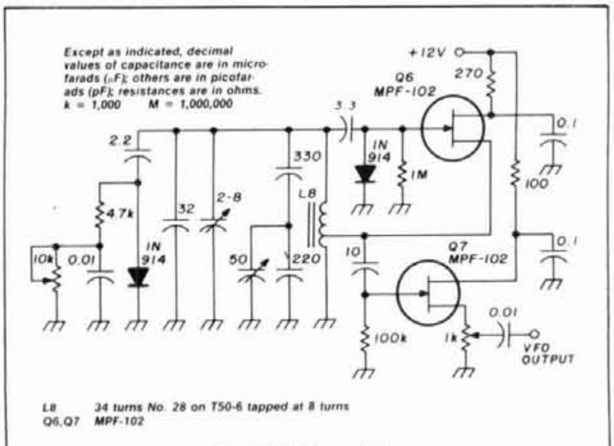


fig. 8. VFO module.

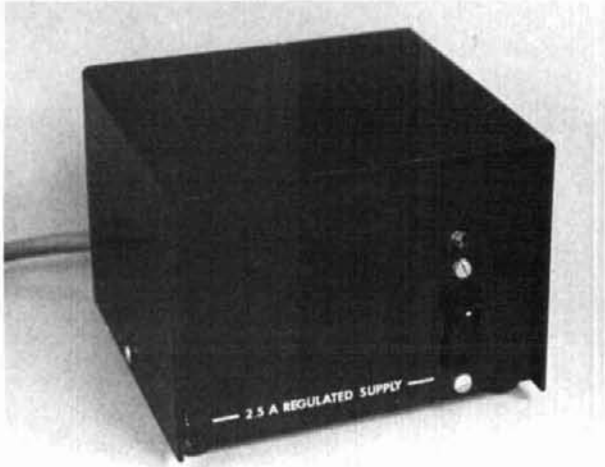


fig. 10. The transceiver's compact power supply measures only 4 × 3 × 3 inches (10 × 7.6 × 7.6 cm). The design is simple, and can be built entirely from off-the-shelf Radio Shack components.

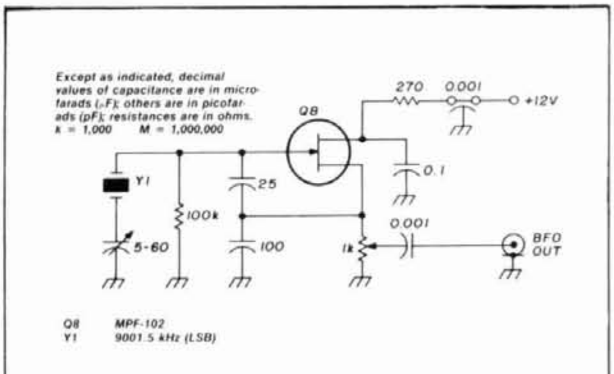


fig. 9. BFO module.

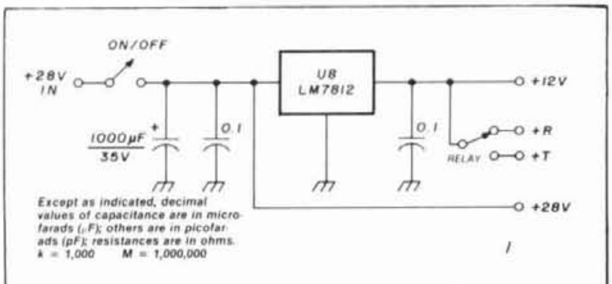


fig. 12. Transceiver on-board regulator.

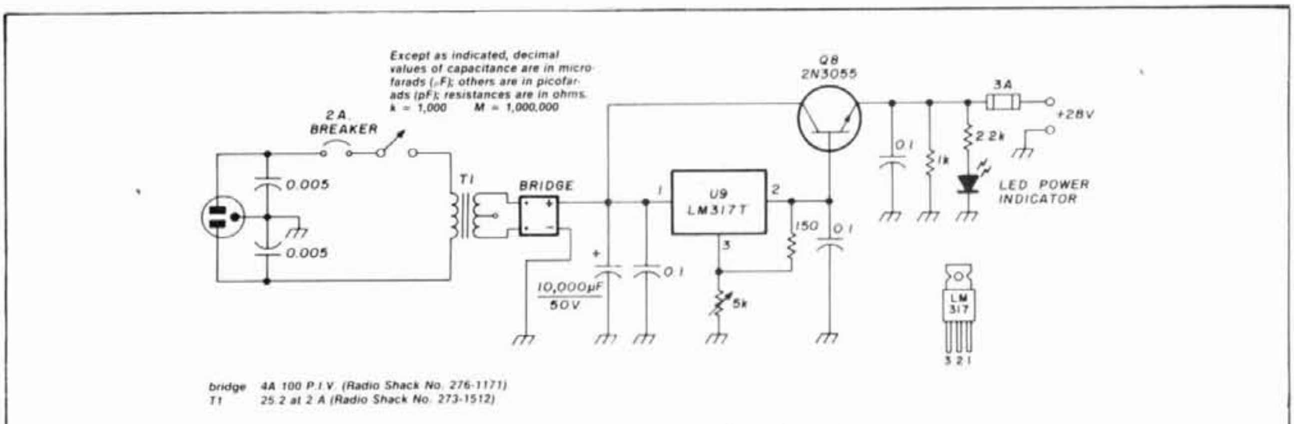


fig. 11. External power supply schematic.

external power supply and schematic shown in **figs. 10** and **11**, respectively, was built from off-the-shelf Radio Shack components. The output of transformer T1 is bridge rectified, filtered, and regulated by pass transistor Q1. Adjustable regulator U1 drives the base of Q1 to set output voltage and to provide additional electronic filtering. An on-board regulator is also incorporated in the transceiver (**fig. 12**).

construction

The boards for this project were laid out in modular strips to facilitate modification during the design pro-

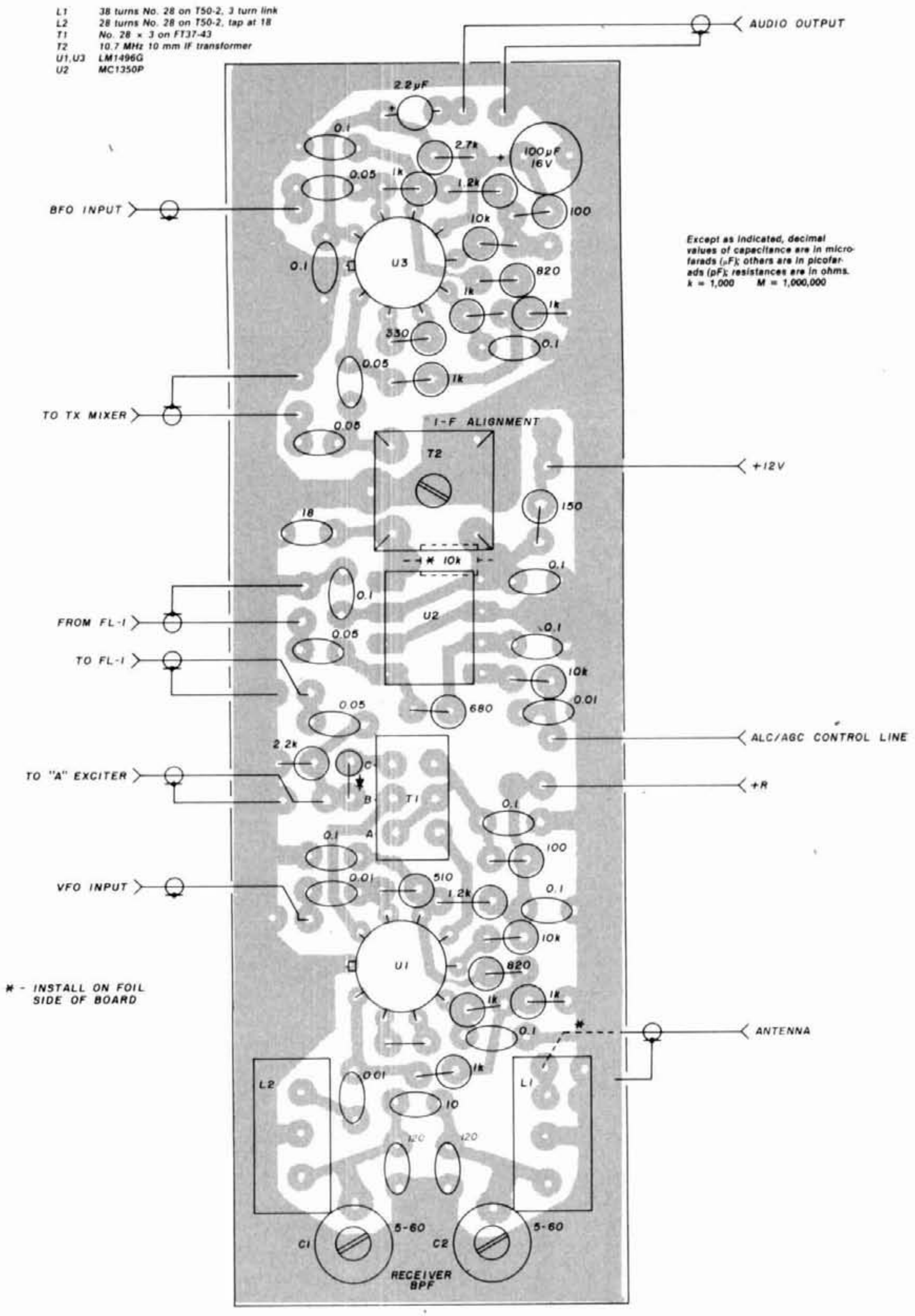


fig. 13. Receiver module.

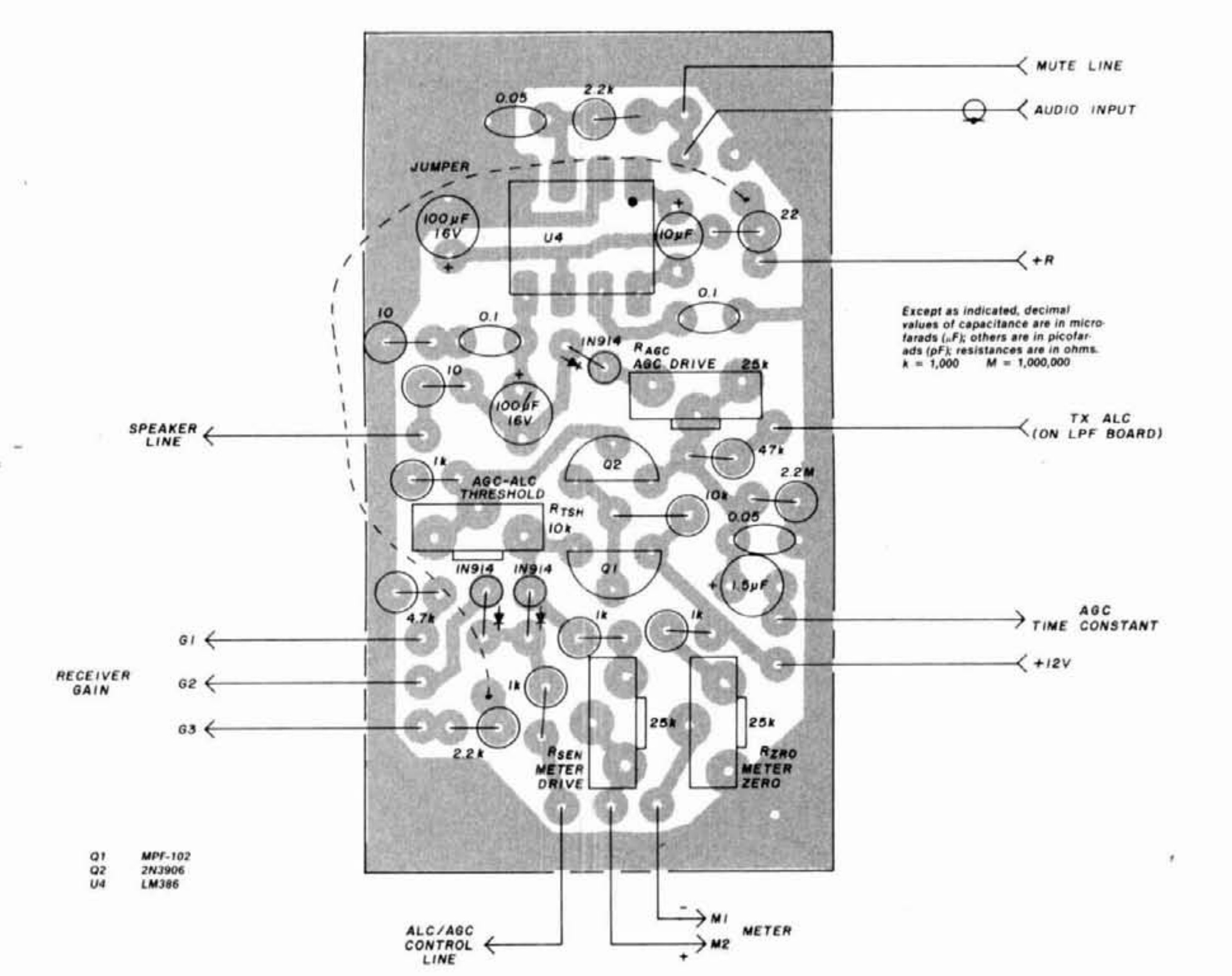
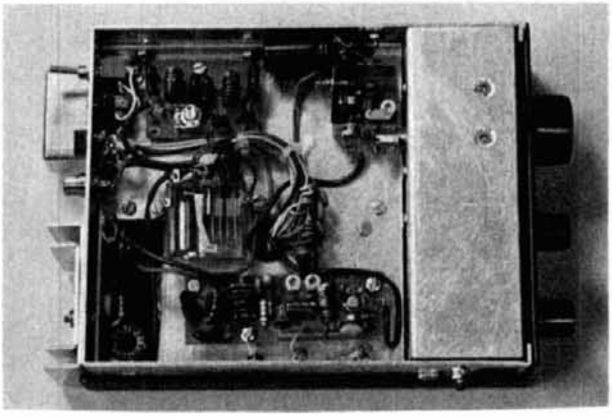


fig. 14. Audio/AGC module.



Bottom view shows BFO, driver, and low-pass filter modules. Voltage regulator is mounted on the side of the case. A 4PDT relay for T-R switching simplifies circuit design and reduces receiver power consumption.

cess. To make the job of interstage wiring easier, the exciter and receiver strips were later joined together.*

Figures 13 (receiver module), **14** (audio/AGC module), **15** (exciter module), **16** (driver/bandpass filter), **17** (MRF-138 final amplifier module), **18** (low-pass filter board), **19** (VFO module), and **fig. 20** (BFO module) show the printed circuit board patterns and component layouts.

Board assembly is routine, but a few specific points deserve mention. The boards were designed around miniature parts. Substituting 1/2-watt resistors, high-voltage capacitors, and other large components can quickly result in overcrowding. Since the parts density is quite high, double-checking parts placement against the schematic or a layout is also recommended.

Use care when winding toroidal transformers and chokes. Most FT (ferrite) cores have rough edges that can easily abrade the insulation from enamel covered

*A complete kit containing all parts, etched pre-drilled circuit boards, punched, painted enclosure, and assembly manual is available from Radiokit, Box 411, Greenville, NH 03048

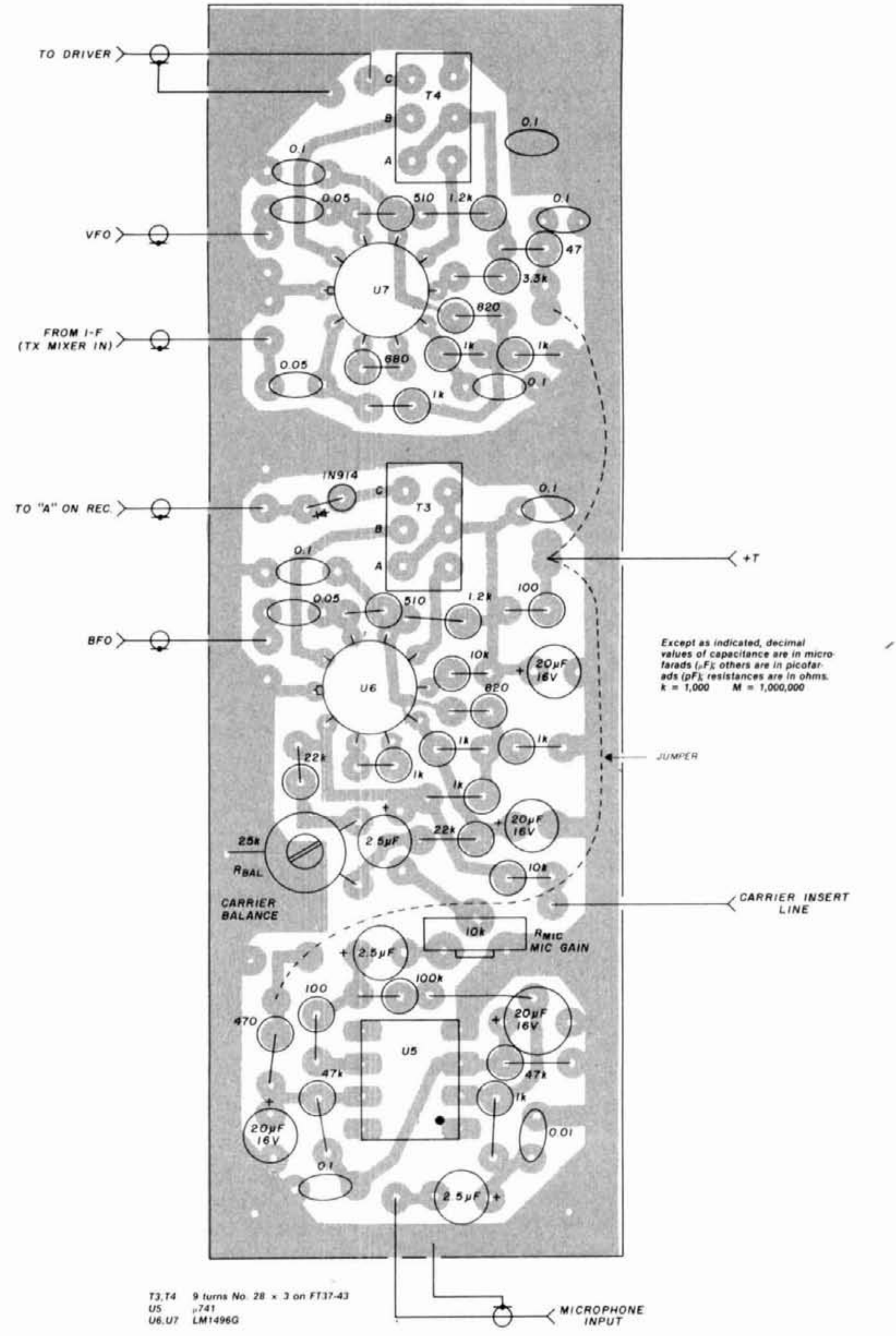
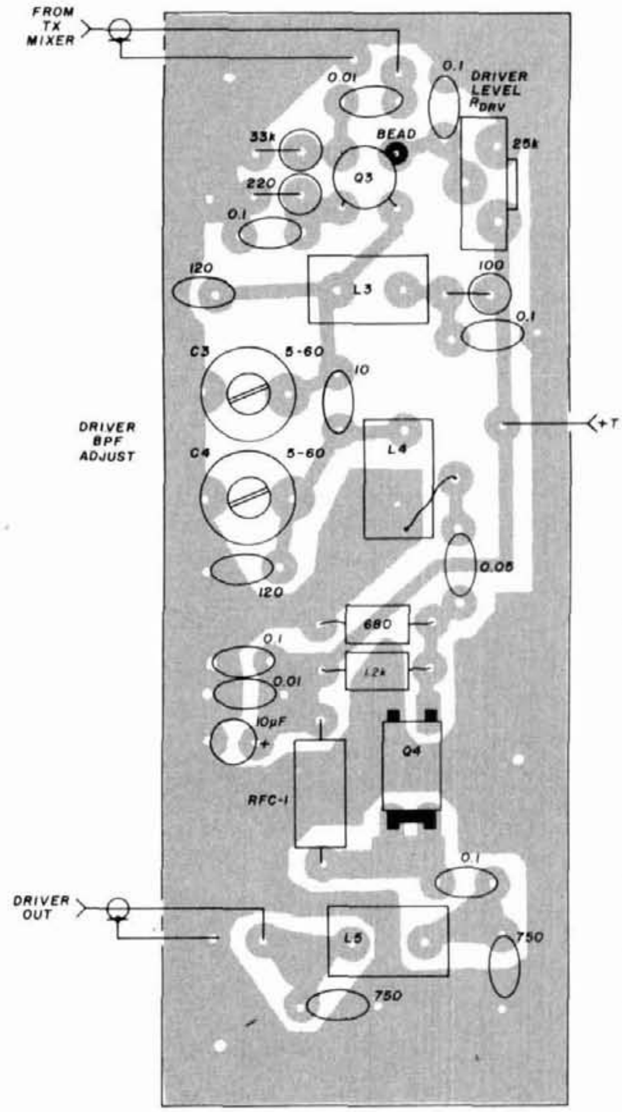


fig. 15. Exciter module.



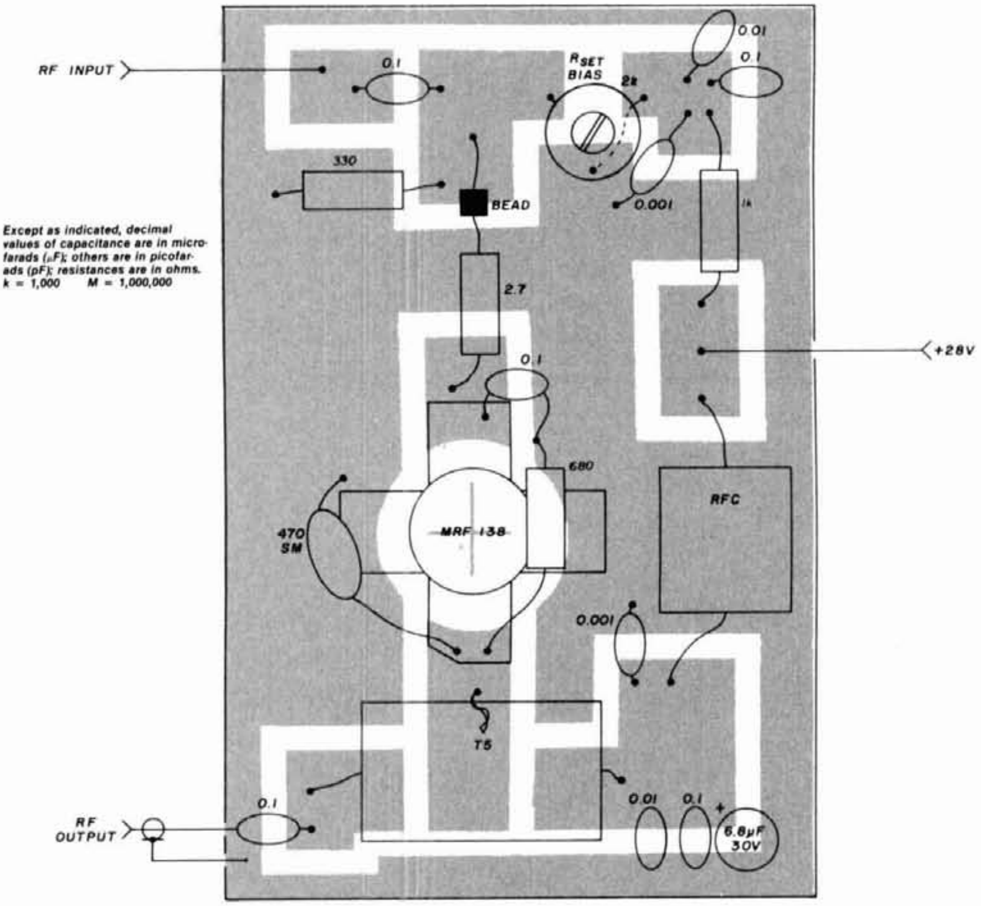
Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms. k = 1,000 M = 1,000,000

L3	40 turns No. 28 on T50-2
L4	40 turns No. 28 on T50-2, tap at 13
L5	21 turns No. 24 on T50-2
Q3	40673
Q4	IRFD-1Z3
RFC-1	10 turns No. 28 on FB43-801

fig. 16. Driver/bandpass filter.

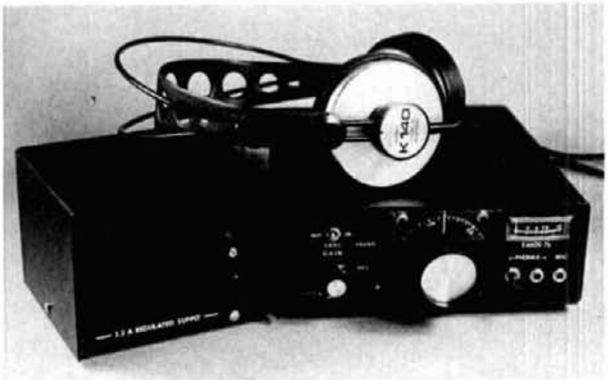
wire. Prepare all FT cores in advance by smoothing the corners and applying two coats of clear nail polish ("T cores are usually epoxy coated and require no preparation). Since most toroid devices have delicate leads that are easily broken, they should be mounted last and glued securely to the board with Ambroid™ cement.†

†T2, a 10.7 MHz 10 mm green-core transformer, is available from Morning Distributing Co., P.O. Box 717, Hialeah, Florida 33011.



RFC 9 turns No. 24 on FB43-801
T5 14 turns No. 24 Bifilar on two FT50-43

fig. 17. MRF-138 final amplifier.



The transceiver can be packaged to suit the builder. The larger cabinet shown here provides more panel space and room for a larger speaker.

Because the VFO circuit is vulnerable to thermal and mechanical instability, its construction requires special attention. These hints should be followed to insure satisfactory performance:

- Use NPO capacitors in the tank circuit wherever possible — the thermal characteristics of silver mica capacitors are often unpredictable.
- To immobilize VFO inductor windings, dip or paint the coil in clear nail polish and sandwich it to the board between fiber washers with a non-inductive screw.
- To insure smooth tuning, the main VFO variable should be a ball-bearing design with either a built-in or external reduction drive.
- The calibration trimmer should be a miniature air-variable (ceramic trimmers drift).
- When installing the VFO module, make all leads connecting external VFO components as short and rigid as possible.
- To avoid thermal instability, locate the VFO away from heat-generating stages such as the PA and the voltage regulator.

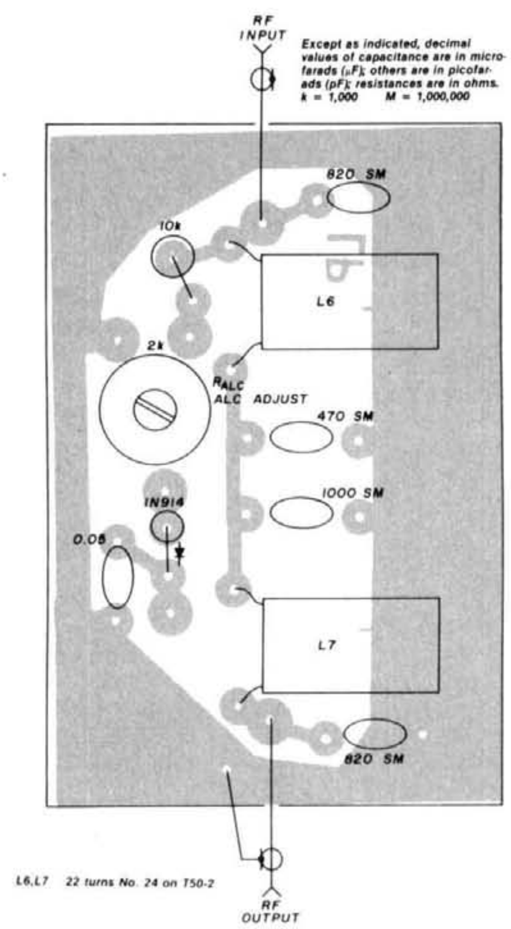


fig. 18. Low-pass filter board.

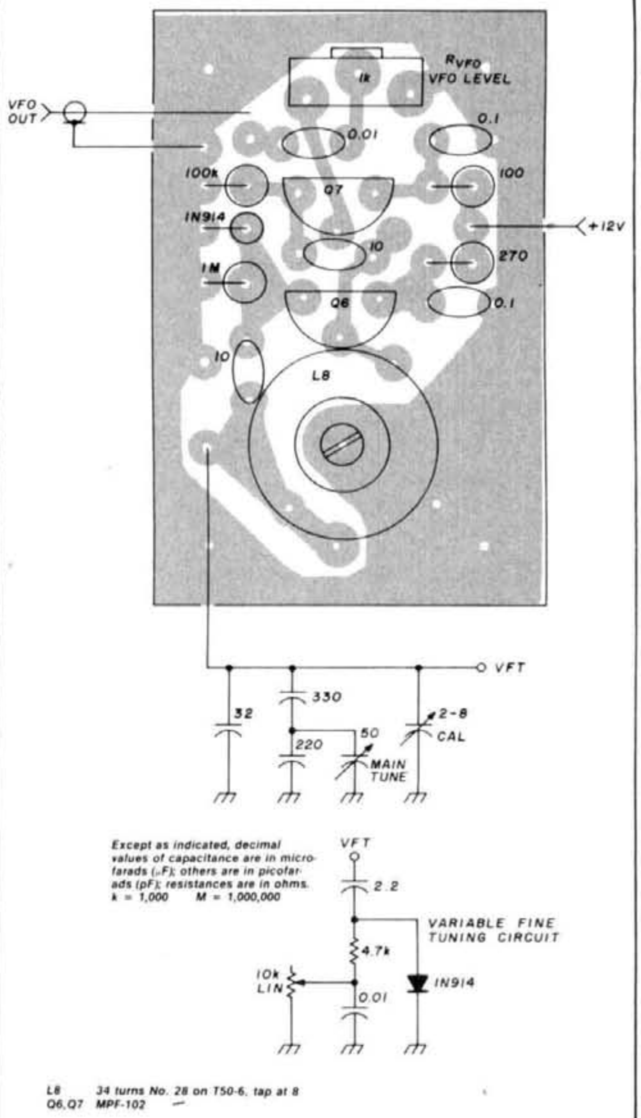


fig. 19. VFO module.

- Shield the VFO compartment against strong RF fields.
- Locate the transceiver's T-R relay away from the VFO compartment. If located too close, the relay's magnetic field will produce an unwelcome frequency shift.

The only other stage requiring special care during construction is the final amplifier. To prevent the possibility of VHF parasitics, strip-line construction is used and components are soldered directly to the top of the board. To insure strong solder connections, each lead should have a short 90-degree bend at its end in order to make flat contact with the board's surface. The transistor should be mounted first. The MRF-138 is an unprotected MOS device, and I recommend using a grounded iron and wrist-strap to prevent static build-up during installation. Once the module is completed, the circuitry will protect the device.

The transceiver cabinet is a bi-level design fabricated in a custom sheet-metal shop. While this packaging contributes to the appearance and small size of the finished unit, much simpler cabinetry is perfectly acceptable as long as a few basic conditions are met. First, all recommendations to insure VFO stability should be observed. Second, the PA module should be mounted to the inside of the back panel with a suitable external heatsink provided on the opposite side. Additional heatsink area is required for extended phone, RTTY, or CW operation. Finally, the VFO and BFO should be fully shielded.

In any modular project, interstage wiring can become a nightmare if the wire is prone to breakage or is difficult to handle. Selecting only highly flexible small-diameter wire and shielded cable keeps interstage harnesses small and manageable. I have found that lavalier microphone cable is smaller and much

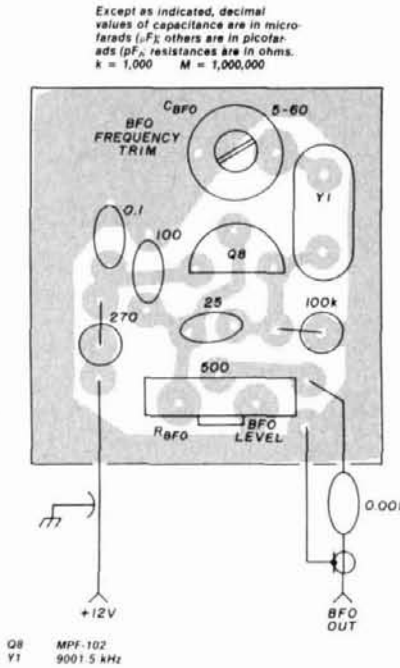


fig. 20. BFO module.

easier to handle than RG-174 miniature coax. Mounting boards on 1/4-inch standoffs also contributes to a neat layout, since this provides space for interstage wiring to pass underneath. Once the modules are mounted and interstage wiring is completed, testing and alignment can begin. Power distribution and T-R switching should be thoroughly checked first, since an error here could damage components.

alignment

Fixed capacitor values in the VFO tank may require some substitution to establish the desired operating range (5000 kHz to 5200 kHz for 4000 to 3800 kHz operation). Once this range is established, a tuning dial can be calibrated. A frequency counter facilitates the calibration process. Once the VFO dial is calibrated, receiver alignment can proceed. Use **fig. 21** to locate the calibration and alignment controls.

- Connect the receive and transmit mixers to the VFO, and adjust R_{VFO} for 100 mV RMS output.

- Connect the product detector and balanced modulator to the BFO, and adjust C_{BFO} for an operating frequency of 9001.5 kHz. Adjust R_{BFO} for an output of 100 mV RMS.

- Set the receiver AGC threshold by adjusting R_{TSH} for 5 volts as measured at TP1. Zero the S-meter via R_{ZRO}.

- Set the receiver gain fully clockwise for maximum gain and adjust IF transformer T2 for a peak in background noise.

- Connect a 50-ohm antenna and tune the VFO to 3900 kHz. Peak bandpass filter trimmers C1 and C2 for maximum sensitivity.

The receiver should now be fully functional. Check AGC action by tuning in an extremely strong SSB signal. If the audio cracks and distorts at full gain, the AGC is under-controlling IF stage U2. Increase AGC gain via R_{AGC} to eliminate this condition. If the audio "pumps" on voice peaks or motorboats with no signal, the opposite conditions exist and AGC gain should be decreased. Meter sensitivity control R_{SEN} should be adjusted so that extremely strong signals register in the upper 10 percent of the scale.

To prepare for transmitter alignment, disconnect the 28-volt supply line from the final amplifier board. Terminate the output of the driver with a 47-ohm resistor and connect a scope across the termination. Microphone gain R_{MIC} should be set fully off, and predriver gain R_{DRV} set to the middle of its range (maximum gain). Tune the VFO to 3900 kHz.

- Key the transmitter and activate the carrier insert switch. Adjust IF transformer T2 and bandpass filter trimmers C3 and C4 for maximum output.

- Key the transmitter and adjust R_{BAL} for minimum carrier output. A receiver tuned to the output frequency may provide a better null indication.

- Connect a 500-ohm dynamic microphone and advance R_{MIC} to 75 percent. Speak into the microphone and watch the scope for signs of instability ("grass" or parasitic oscillations on the waveform). The pattern may show flat-topping on voice peaks, since the ALC is not yet functional.

If instability or parasitics are observed, find their source before going on. Check the RF amplifiers in isolation, and check IF amplifier U2 (reducing the value of the 10-kilohm resistor across the primary of T1 should tame unstable operation in U2). If operation is normal through the driver stage, alignment can continue.

- Connect the 28-volt supply line to the final amplifier board through an ammeter. Short the amplifier's input terminal to ground. Key the transmitter, and adjust R_{SET} for an idling current of 250 mA. Note that this adjustment is sensitive to changes in supply voltage. If the power supply voltage is changed significantly at a later date, the bias should be re-set.

- Remove the driver termination, unshort the input to the PA, and hook up the driver. Connect a 50-ohm dummy load to the output of the transceiver. Place a single turn pick-up loop through balun T5, and connect it to the scope. The driver low-pass filter and bandpass responses are shown in **figs. 22A, B**.

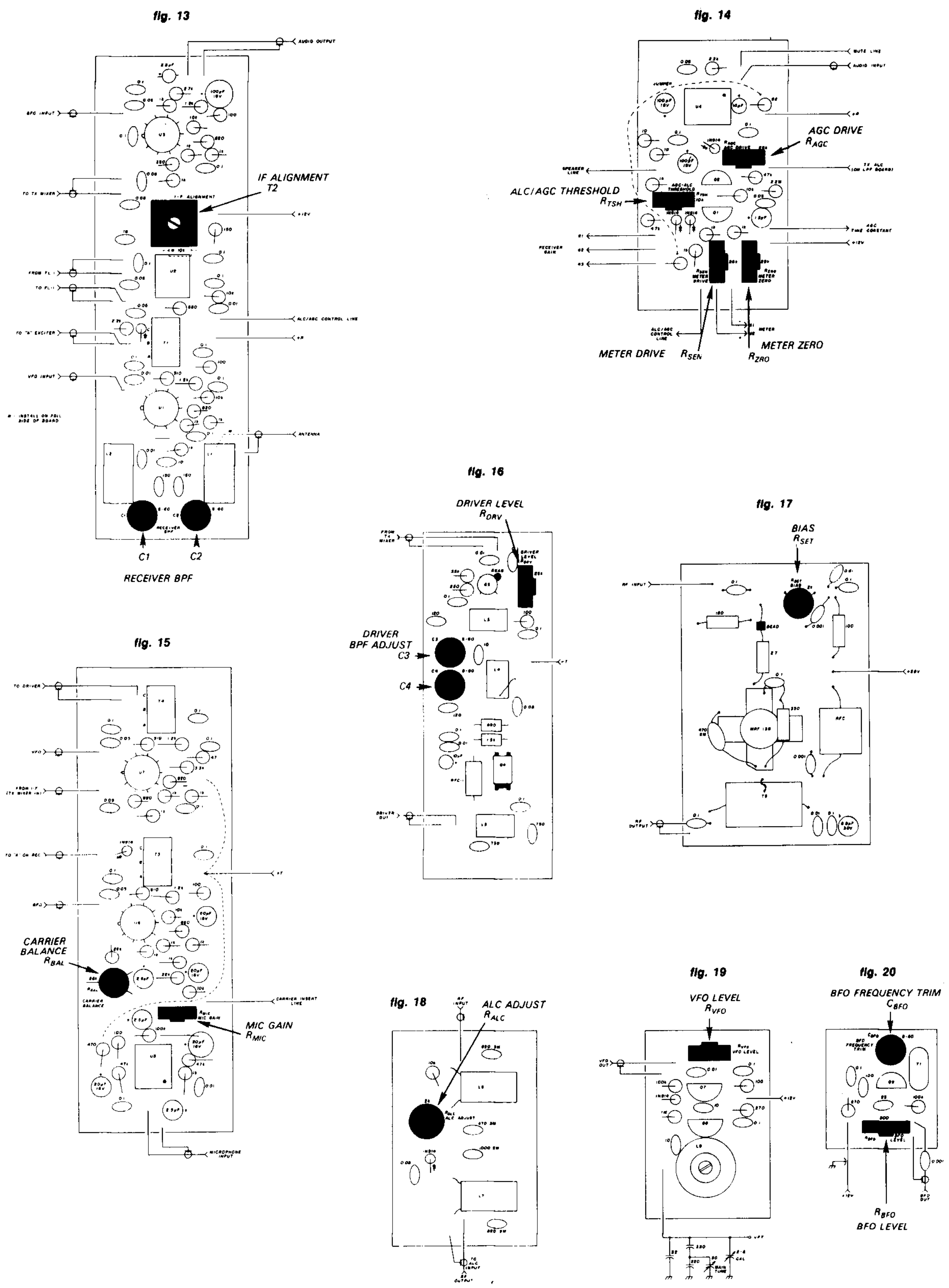


fig. 21. Calibration and alignment controls.

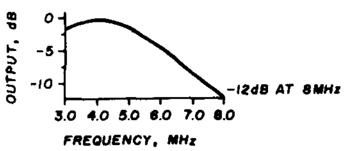


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fig. 22A. Driver low-pass filter response.

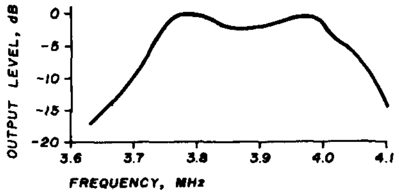

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fig. 22B. Driver bandpass filter response.

• Key the transmitter and speak loudly into the microphone, adjusting R_{ALC} for maximum transmitter output. The scope pattern should show flat-topping on voice peaks. If saturation does not occur, increase microphone gain until it does. If the final cannot be saturated, system gain is low and a problem exists (check the AGC threshold voltage at TP1 first; if set above 5 volts, transmitter gain is reduced).

• To set ALC level, close-talk the microphone and adjust R_{ALC} to the point where flat-topping just disappears. The ALC meter should deflect past mid-scale on voice peaks and a power meter should indicate an average output of 10-15 watts.

This completes transceiver alignment.

performance

The transceiver was tested to see if performance approximated industry standards and met FCC regulations for spectral purity. Receiver noise floor was measured at −120 dBm. Selectivity reflected the published specifications of filter FL1. AGC held a 60 dB change in signal strength to a 3 dB change in audio output. AGC attack was a bit slow, resulting in some audible "cracking" on extremely strong signals. This condition is not uncommon in simple audio-derived systems. Overall receiver audio quality was judged excellent when compared against a popular imported multi-band transceiver. Tests for receiver intermodulation distortion were not conducted.

At 30 watts PEP output, transmitter IMD was measured at −30 dB. Second and third harmonics were −47 dB and −55 dB, respectively. Saturation occurred at 35 watts PEP. Transmit audio reports were generally excellent, but microphone selection was an important factor. Low-Z broadcast dynamics produced the best overall quality, but an inexpensive mobile microphone provided a bit more "punch" under difficult band conditions. The MRF-138 final amplifier survived open and shorted port conditions without damage, indicating acceptable immunity to high SWR.

operation

The transceiver's small size makes it a natural for traveling, or for use as a second station at home. Mine resides in a corner of the family room on a small writing desk, close to the wood stove, kitchen, and other comforts of home. On-air performance has been very gratifying. Using an inverted-V antenna at 50 feet, I have worked all U.S. call areas, operated contests, controlled nets, and elbowed my way through evening QRM with excellent regularity. In evaluating the transceiver's effectiveness, it is important to remember that dropping transmitter output from 100 watts to 30 watts reduces the received signal less than 1 S-unit. Under most band conditions, this is not significant.

conclusion

My goal was to design and build a simple monoband SSB transceiver that would be compact, easy to replicate, and powerful enough to provide reliable communication on 75 meters. Off-the-shelf components and contemporary design techniques were employed wherever possible to make the job easier. The transceiver described in this article is my third, and carries with it the experience of the first two. With minor modifications, the design should be transferable to other bands. I hope this article will encourage others to take the plunge and build — there's no magic involved, and the enjoyment that comes from operating a homebrew rig is fantastic.

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ham radio

high stability local oscillators
for microwave receivers and other applications

Phase-locked approach offers greater stability

This article describes a reliable phase-locked loop originally designed for the first conversion of a radio astronomy microwave receiver[1] applicable for general microwave receiver use and to other HF, VHF, and UHF phase-locked applications as well.[2] Its design evolved from one of my earlier efforts incorporated in a fully synthesized, general coverage HF transceiver as shown in **fig. 1**.

Local oscillators used for conventional microwave (TVRO) such receivers are usually open loop and are installed outdoors as part of the first converter, known as the "head end" and located at the feed point of a parabolic dish antenna. They normally exhibit gross frequency instability (typically ±1.5 MHz) due to their free running characteristics, which are affected by ambient temperature changes as well.

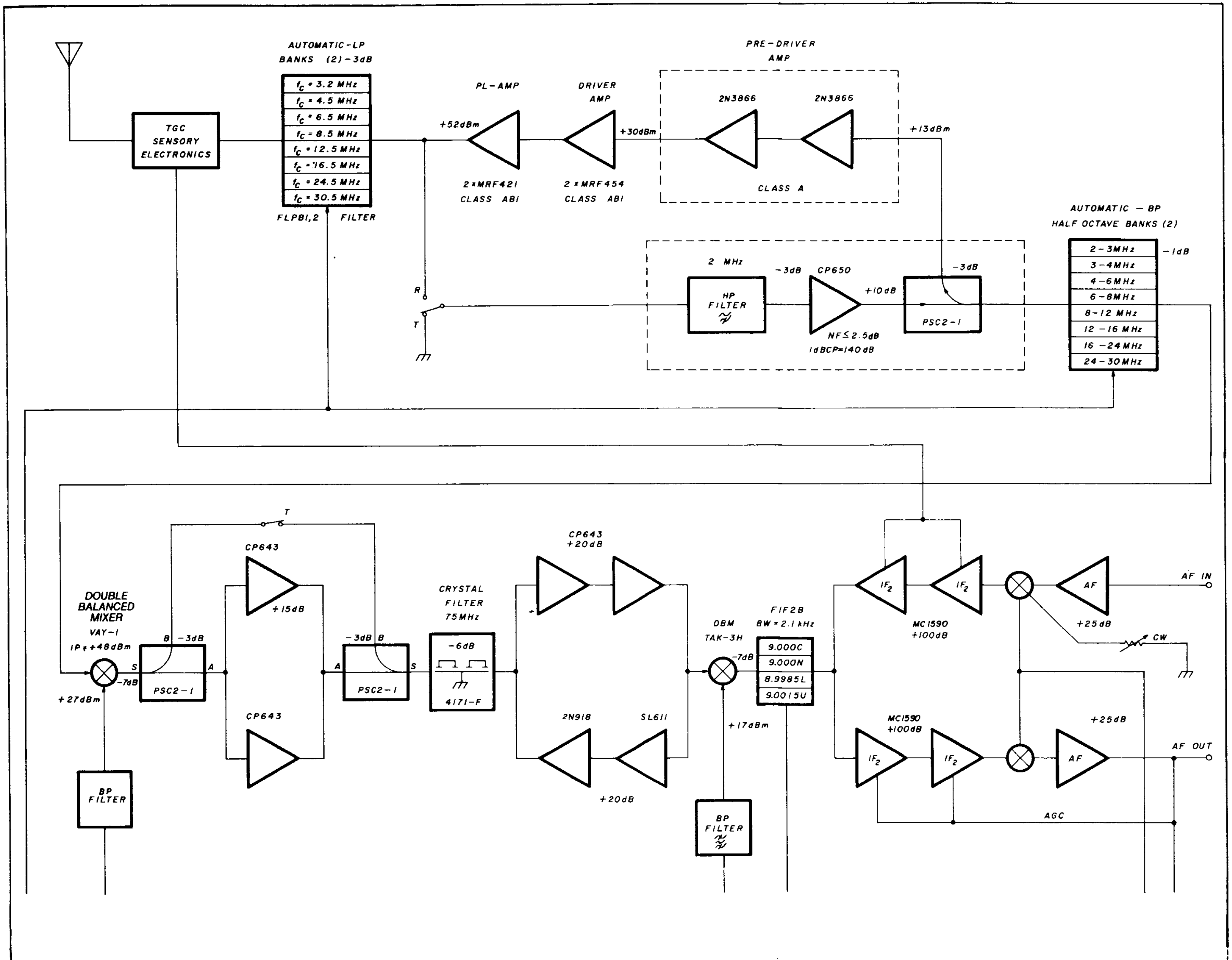
The two types of open-loop local oscillators most commonly used for this application are the free running tuned cavity and the crystal controlled multiplier type. This article deals with the second approach, which allows an already-clean multiplier chain to lock on a much more stable reference frequency strategically located away from the elements. Consequently, the unit can be used under varying temperature conditions and will follow a remote reference source kept indoors for good stability.

The synthesizer uses a simple version of a type-one crystal-controlled phase-locked-loop operating at 88 MHz.[3] Its output is divided by a fixed modulus divider involving emitter-coupled-logic (ECL) and transistor-transistor-logic (TTL) circuits. The division number N is fixed at 88 and followed by an exclusive OR digital phase detector that closes the loop through a simple low-pass filter as shown in **fig. 2**.

In order to obtain the desired microwave frequency, the output of the oscillator running at exactly 88 MHz is used to drive a times-12 multiplier such as described by Paul Shuch, N6TX.[4] Other multiplications are possible for even higher frequencies. The reference frequency can be supplied to the synthesizer from the back end of the receiver via fiber optics or coaxial cable communication links (depending on the distance; digital line drivers may be required in the latter). With this approach, a remotely located temperature-compensated crystal oscillator (TCXO) that acts as a time base will maintain the short and long term frequency stability of the 88-MHz crystal oscillator through the phase-locked technique. The stability of the multiplier chain in the microwave receiver will thereby also be favorably affected. High initial stability and spectral purity would be required to compensate for the magnifying effect of the multiplier. My circuit used a 4-MHz TCXO manufactured by McCoy Electronics for the reference oscillator. This part guarantees $\pm 5 \times 10^{-7}$ (±0.5 PPM or ±2 Hz at 4 MHz) Hertz per year.[2] This represents an ultimate stability for the remotely located L-band local oscillator of ±6 Hertz, respectively.

The circuit design of the synthesizer is simple (although making one work is another story) as shown in **fig. 3**. A highly stable 88-MHz (0.001 percent) fifth overtone crystal was chosen to guarantee initial start-up almost on frequency before locking occurs. It is

By Cornell Drentea, WB3JZO, 7140 Colorado Avenue North, Brooklyn Park, Minnesota 55429


AUTOMATIC-LP
BANKS (2)-3dB
fc = 3.2 MHz
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fc = 6.5 MHz
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fc = 12.5 MHz
fc = 16.5 MHz
fc = 24.5 MHz
fc = 30.5 MHz
FLPB1,2 FILTER
TGC
SENSORY
ELECTRONICS
PL-AMP
+52dBm
2 x MRF421
CLASS AB1
DRIVER
AMP
+30dBm
2 x MRF454
CLASS AB1
PRE-DRIVER
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2N3866
CLASS A
+13dBm
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T
2 MHz
HP
FILTER
-3dB
CP650
+10dB
NF≤2.5dB
1dBCP=140dB
-3dB
PSC2-1
AUTOMATIC - BP
HALF OCTAVE BANKS (2)
2-3MHz
3-4MHz
4-6MHz
6-8MHz
8-12 MHz
12-16 MHz
16-24 MHz
24-30 MHz
-1dB
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CP643
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CP643
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2N918
SL611
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TAK-3H
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+17dBm
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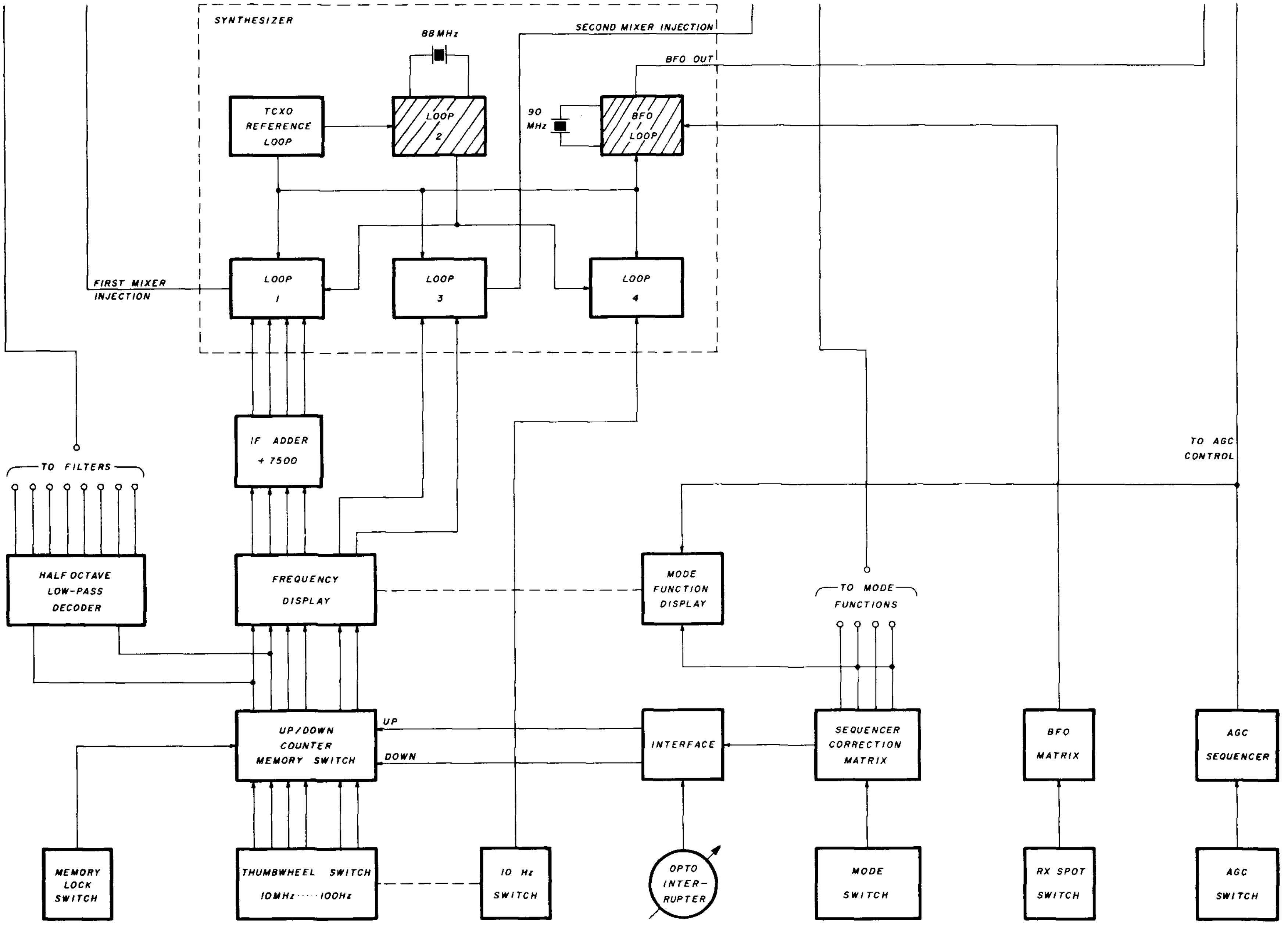


fig. 1. Application of fixed VHF phase-locked-loops in a fully-synthesized HF transceiver. The VHF loop described here is used twice (88 MHz and 90 MHz for the BFO) in order to ensure full synthesis for the entire radio.

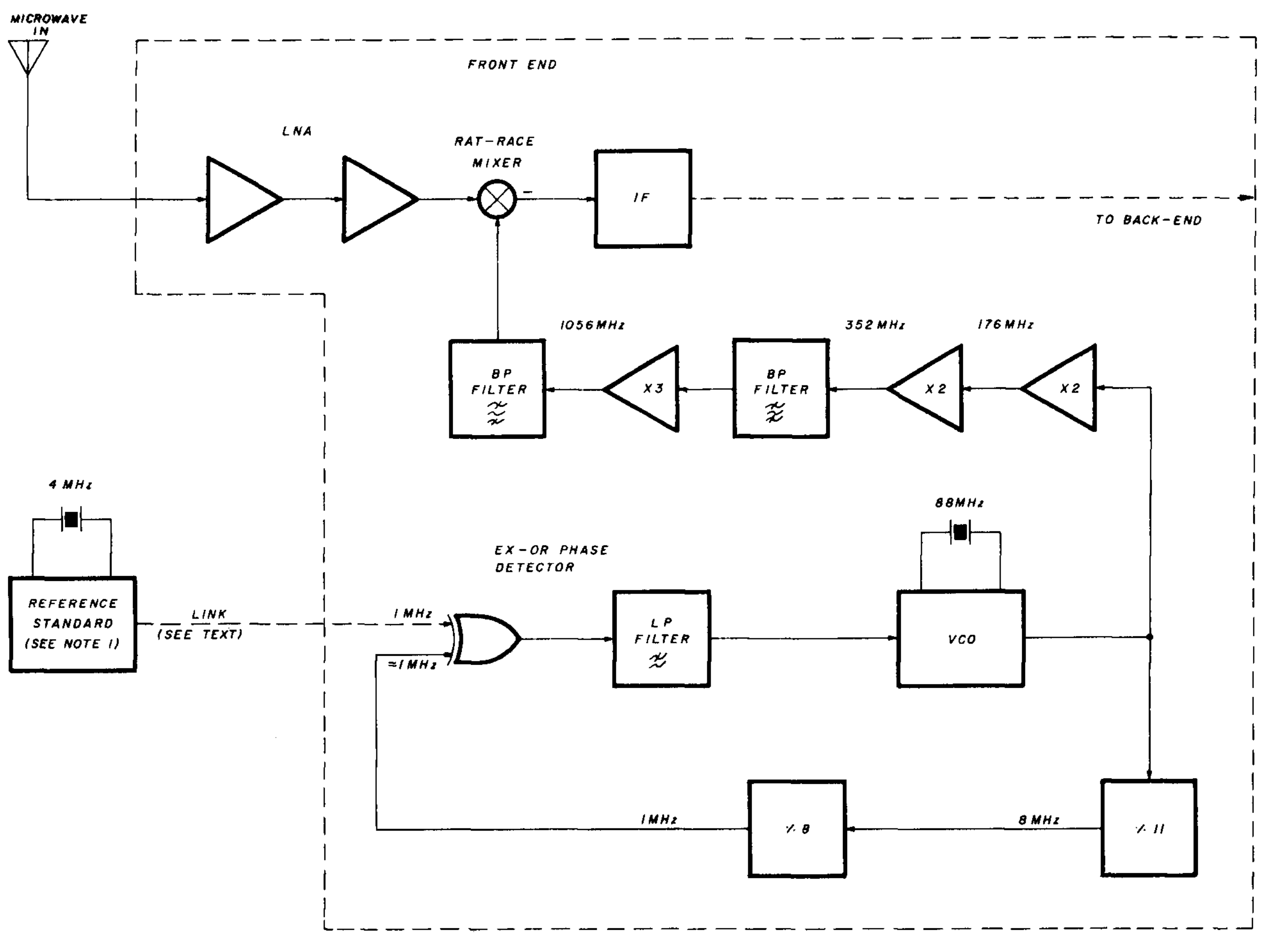


fig. 2. Block diagram of the phase-locked-loop as used in a stable microwave local oscillator located at the low noise block converter (LNB) outdoors. The 1 MHz reference frequency is derived from an indoor TCXO.

used in a series resonant Colpitts oscillator with one side of the crystal grounded. I selected the Colpitts design because of its well known circuit stability and predictability.[5] The output of the oscillator is then amplified and converted to the ECL level required by the 95H90 divide-by-11 device.[6,8]

An ECL-to-TTL level shifter circuit follows the 95H90 and additional division is obtained with three divide-by-2 sections of 74LS74 devices.

The divided-down 1-MHz input to the phase comparator 74L86 (slow L logic was chosen here to keep the output as quiet as possible) is compared against a true 1-MHz reference available from the back end. The exclusive OR phase detector was chosen as a perfect application for this type of phase-locked-loop because the crystal controlled Colpitts oscillator is guaranteed to start almost on frequency and within the capture range of this particular type of phase detector which is only 2π.[2,3,7] Other important criteria for choosing this type of phase detector were the 50 percent duty cycle of the signals present at its inputs and the high reference frequency (1 MHz), all design requirements for successfully using an exclusive OR gate as a phase detector.[7]

When the loop is locked, the output of the phase detector is a 50 percent duty cycle square wave at twice the reference frequency; in this case it is 2 MHz as shown in **fig. 4**. This output is averaged by the simple RC low-pass filter with a corner frequency (ω_η) of about 16 Hz and is finally presented to the Amperex varactor diode BB-109, which acts as a variable capacitor steering the crystal oscillator in lock. Under locked conditions, the averaged DC output of the phase detector equals half of the TTL supply voltage, or about 2.5 volts DC. When this occurs, the divided 1-MHz signal present at one of the phase detector inputs lags the reference 1-MHz signal present at the other input

*Among many ECL dividers, the 95H90 or its equivalent, the Plessey SP8640 can be programmed to be divide-by-10 or 11, or both in high resolution dual modulus phase-locked-loops.[2]

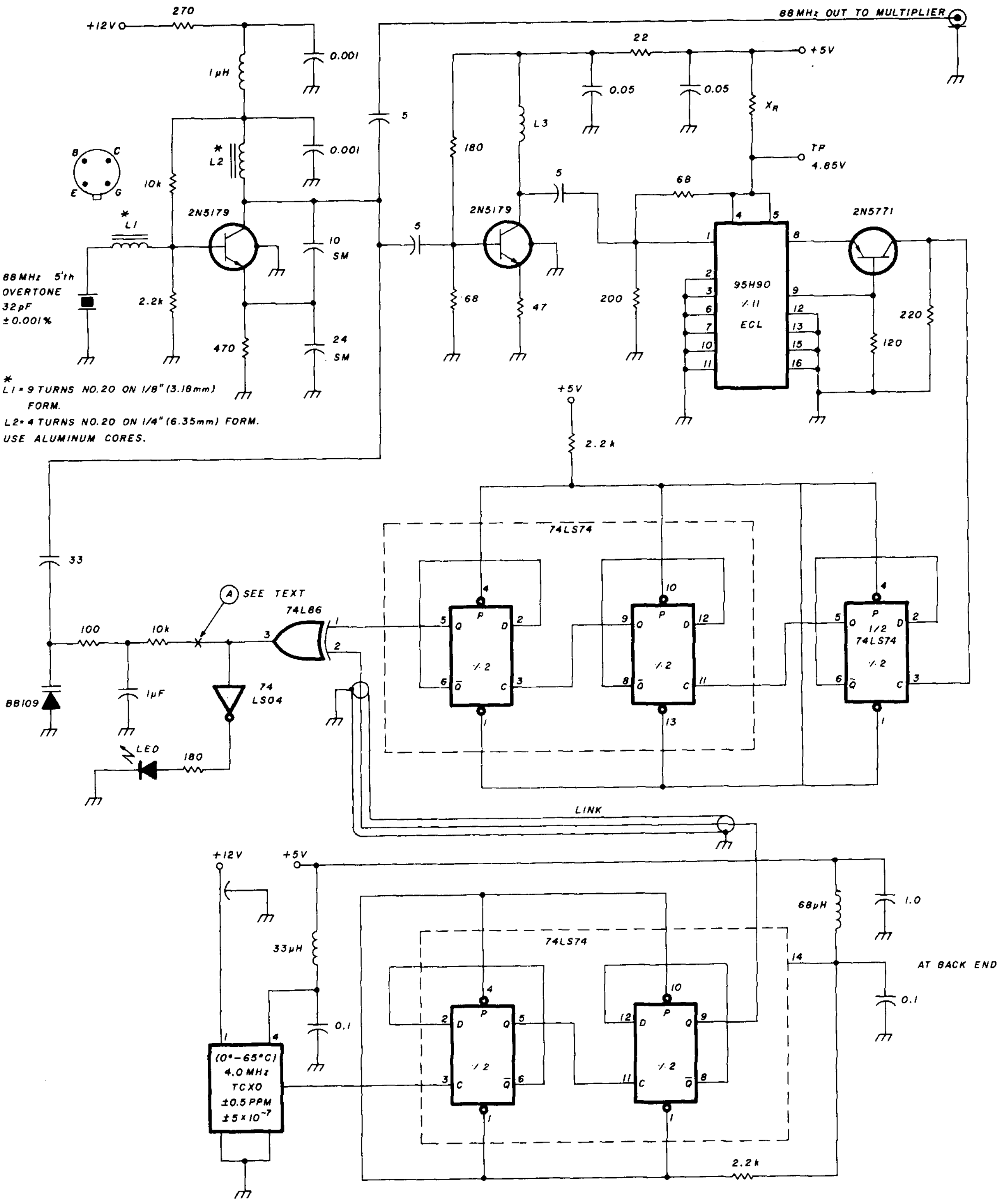


fig. 3. Circuit diagram of the phase-locked-loop. A fifth overtone series-tuned Colpitts oscillator was chosen for stability. The design results in simple and effective exclusive OR phase detectors and low-pass filter. The relatively high 1 MHz reference allows for clean and stable LOs (see text).

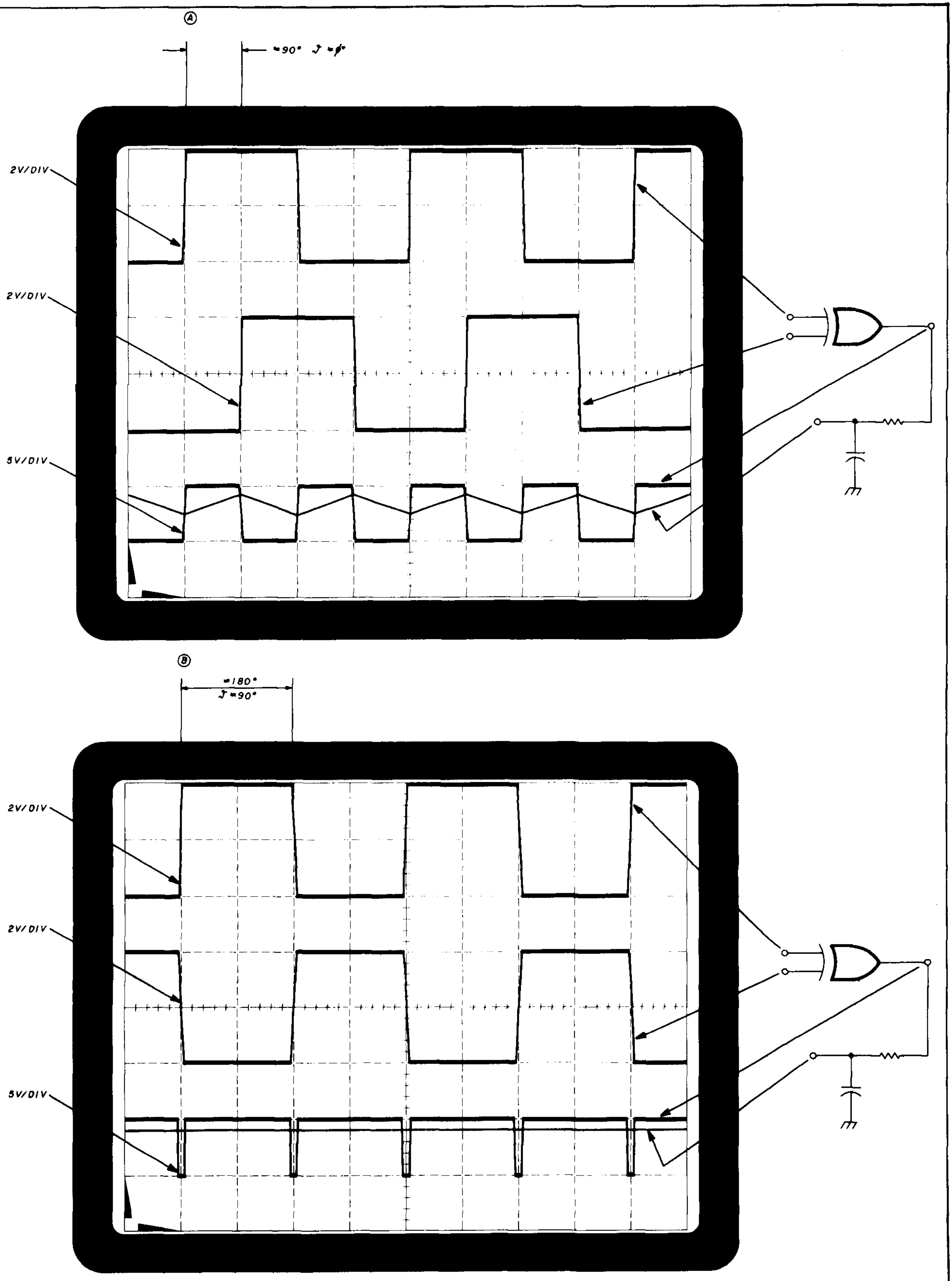
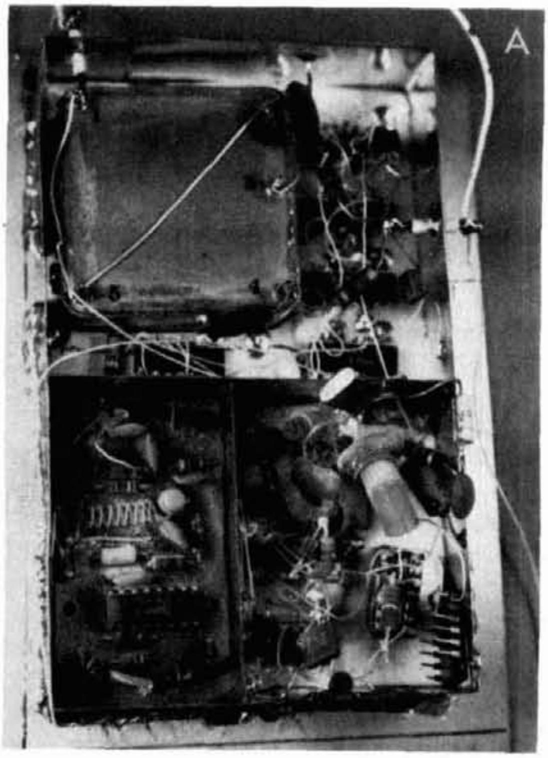


fig. 4. (*A*) Locked condition. (*B*) Out-of-lock conditions for a synthesizer using the exclusive OR phase detector. The output of the low-pass filter is a 2.5 volts DC signal (see text).



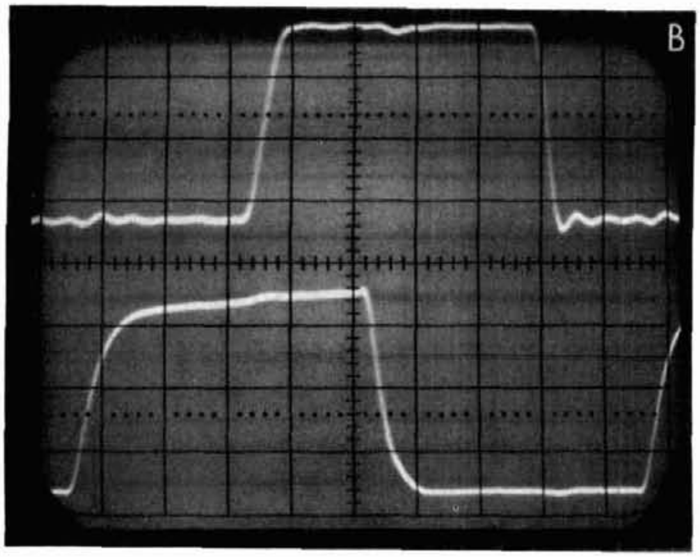


fig. 5. (*A*) The synthesizer circuit was frozen to −78 degrees F with cooling spray. (*B*) After calibration the phase-locked-loop remained locked over the entire temperature range. The divided 1 MHz square wave shown at the top follows the reference frequency at the bottom by −90 degrees, which represents a 0-degree phase error (see text).

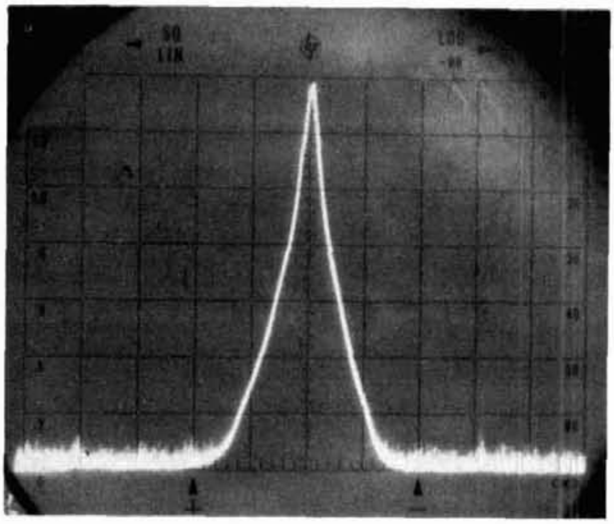


fig. 6. Spectrum analyzer tests performance of the phase-locked-loop.

by approximately 90 degrees (delay is introduced by the additional circuitry) which corresponds to a zero phase error.[3] The secret of the entire circuit is L1 and L2, which are calculated to resonate the Colpitts oscillator on the fifth overtone of the crystal. Additional "tweaking" may be required to bring the circuit into resonance due to local stray elements. High *Q* aluminum cores were used in my prototype for best results.

adjustments

With the loop line disconnected at A (see **fig. 3**), inject a 2.5 VDC level at the 10 kilohm resistor (which is part of the low-pass filter. The best way to do this is to use a couple of batteries in series through a 10-kilohm linear potentiometer voltage divider to insure a pure DC voltage. With the circuit board heated to 80-degrees F (a 100-watt lamp on top of the circuit will do well), adjust L1 and L2 for resonance at the fifth overtone of the crystal as measured on a frequency counter. Observe the position of the cores. Cool the circuit to −78 degrees F with a dry cooling spray. Adjust L1 and L2 again for resonance. (The circuit should still work at this temperature; according to calculations, the transistor junctions will reach only about −40 degrees F.) To accomplish this, selected parts have been used in the prototype. Again, observe the new position of the cores.

Wait until the circuit returns to room temperature and readjust L1 and L2 midway between the two positions. Remove the 2.5 VDC voltage from the low-pass filter and reconnect the loop back at A.

The circuit should now lock every time power is turned on and lock should be maintained over the entire temperature range. This can be verified through repeating the above procedures with the loop closed.

Figures 5A and **B** show the "brassboard" of the synthesizer and how phase locking was maintained under freezing conditions. For convenience a lock indicator was incorporated in the design as shown in **fig. 3**.

An out-of-lock condition would be indicated by the blinking LED, should recalibration become necessary.

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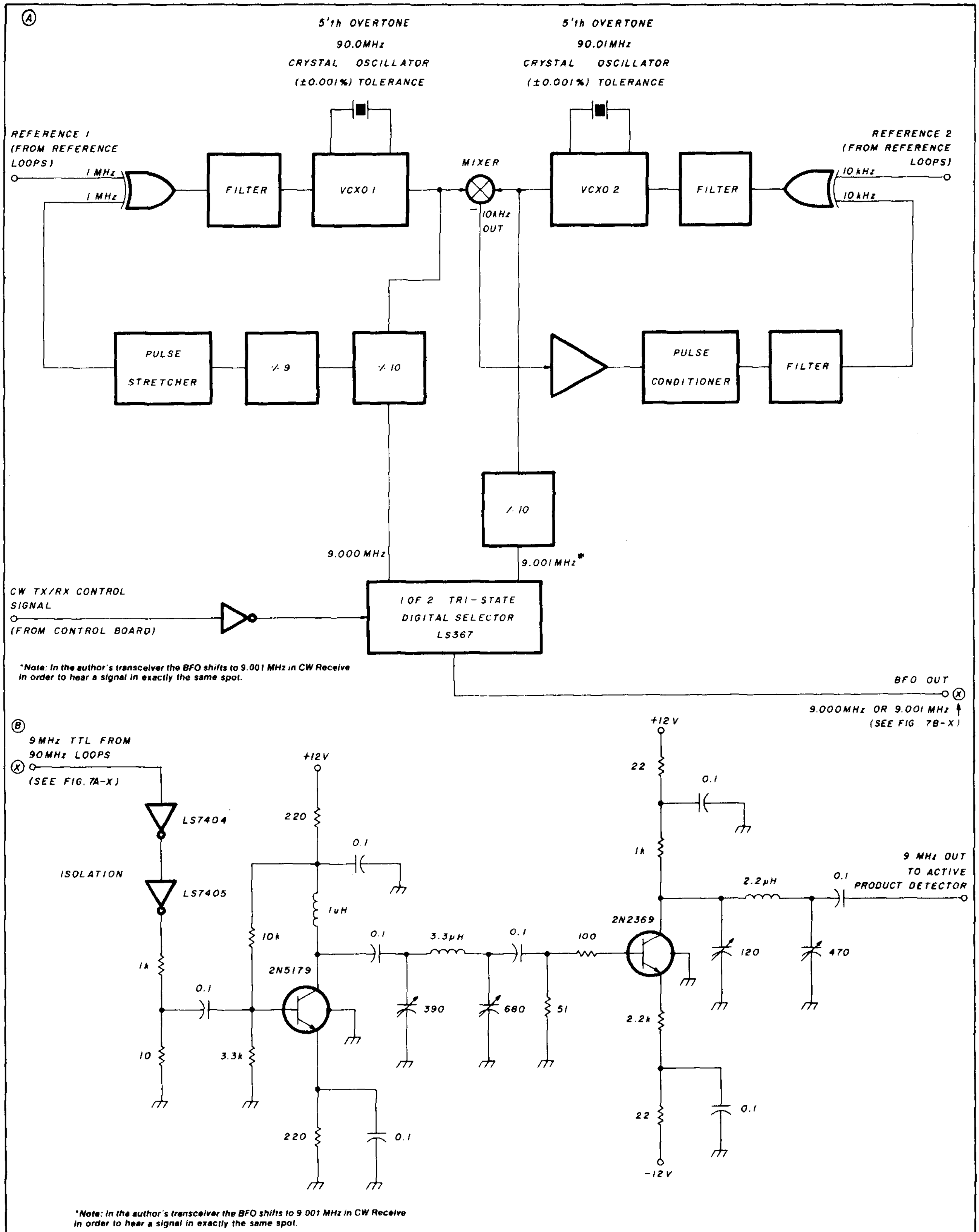

fig. 7. (*A*) Block diagram of an elegant 9 MHz BFO as used in a fully synthesized HF transceiver. The signal is derived from a dual 90 MHz phase-locked-loop similar to the one presented here (see text).
(*B*) Signal processing for the 9 MHz BFO. The 90 MHz derived signal is conditioned before it is applied to the active mixer product-detector/modulator.

If the circuit is to be used at room temperature, such as in an HF or VHF/UHF receiver, no indicator should be required. Other status reporting features are possible and can be remotely monitored at the back end of the microwave receiver.

This synthesizer represents an effort of several weeks of design and "brassboarding." It began with the use of a 54S124 dual VCXO integrated circuit that was intended to work at 85 MHz, but was not successful for my application because of the crystal frequency restrictions and the limited upper frequency range for this device.

The new design will work to about 140 MHz (1680-MHz LO output when used with the N6TX multiplier, and beyond with other multipliers). Its limitations are the fabrication of crystals at VHF frequencies and the rather small size of L1 and L2 at the higher frequencies.

This design represents a practical approach to clean and stable local oscillators. Phase and amplitude noise have been measured to be at least −70 dB/Hz at ±100 Hz from the desired carrier (see **fig. 6**). Discrete spurious components were better than −60 dB, while the wide band noise was at least −70 dB measured with a 10-kHz bandwidth.

These specifications depend on the application of sound RF design techniques and may vary according to the circuit components selected. Although a synthesizer layout is not provided in this article, compartmentalization of modules in a true "synthesizer fashion" is highly recommended.

As suggested at the beginning of this article, other than microwave applications of this synthesizer are possible. Among them are beat frequency oscillators (BFO) and fixed oscillators used in multi-loop fully synthesized HF and VHF/UHF receivers and transceivers, as shown in **fig. 1**. **Figure 7A** shows the block diagram of a 9-MHz BFO application as used in my HF transceiver. **Figure 7B** shows the circuit details of the digital to analog portion of the BFO which provides the proper injection to an active product detector/modulator in my transceiver. Many other applications are possible.

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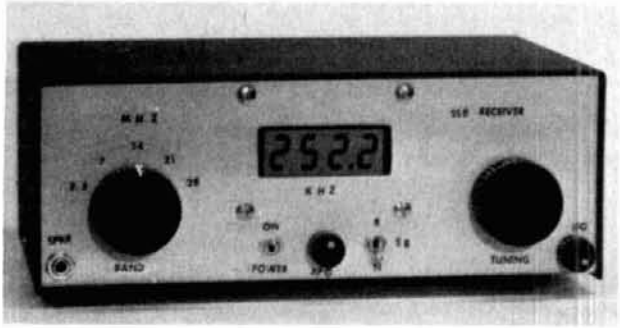


10 through 80-meter homebrew receiver

Even the beginner can build and understand these circuits

If you're looking for a ham band receiver that combines good performance with simplicity of construction and low cost, read on — because this article is for you. This receiver covers the 80, 40, 20, 15, and 10 meter bands and can easily be modified to include the WARC bands or other shortwave segments between 3 and 30 MHz.

This project evolved in response to discussions with other hams about the deplorable decrease in the number of new Amateurs. Traditionally, a large part of our newcomers have come from the ranks of high school students; at one time, young people interested in the electronics almost inevitably gravitated to Amateur Radio because it was easy to get into, with little technical knowledge and only a small investment required. In recent years, the computer hobby with its inexpensive, easily accessible hardware — has provided similar easy entry.

Many hams have expressed the opinion that entry-level equipment has become too expensive and that construction articles now seem to deal with equipment that is complex, expensive to build, and requires a great deal of technical sophistication to construct. This started me to thinking about what it would take to build a receiver for the main ham bands that would provide good performance, yet be simple and inexpensive to build.

the VFO is important

In the 1950's and 60's most receivers used oscillators that switched coils for each band. In later years, however, multiple conversion schemes used crystal oscillators to establish each band and one non-switched oscillator as the variable frequency element to tune within each band. Many receivers now use frequency synthesized oscillators. These latter two concepts, while improving stability, unfortunately increase cost and complexity by a substantial amount.

Recalling more recent commercial rigs, such as the Atlas series, that used switched coil oscillators, I wondered how difficult it would be to design and construct a VFO that had acceptable stability for SSB reception (see **fig. 1**). After deciding it was worth a try, I chose 9 MHz as the IF because of the wide availability of good, inexpensive crystal filters at this frequency. For maximum utility I wanted coverage of both the CW and SSB portions of each band. The VFO covers 500 kHz on 80 through 15 meters and over 1 MHz on 10 meters. As we will see later, these ranges can be easily changed to suit the user's preference.

The choices for the IF and band ranges determine the VFO frequencies as follows:

band meters	VFO frequency MHz
80	12.5-13.0
40	16.0-16.5
20	5.0- 5.5
15	12.0-12.5
10	19.0-20.0

Varactor diode tuning of the VFO was chosen because it helps eliminate hard-to-find mechanical

By Robert Thompson, N1BFV, 4 Owens Brook Circle, Simsbury, Connecticut 06070

variable capacitors as well as the mechanical linkage they require. It also allows size reduction by eliminating the bulk of a variable capacitor and allows significant reduction in the overall mechanical complexity of the VFO unit. One disadvantage of varactors, however, is that they require a tuning voltage as close to pure DC as possible. I therefore decided to use a 9-volt alkaline battery on the prototype. This led to thoughts of running an entire receiver on batteries, in the interest of even greater simplicity.

Since the VFO frequencies for 80 and 15 meters are close, one coil was used for both (see **table 1**). The VFO coils could have been switched electrically with diodes, but doing so would have taken about 30 mA of additional current from the main battery supply. A rotary switch was chosen for current economy.

board construction

The VFO, the frequency counter, the BFO, the bandpass filter, and the IF unit are all constructed in a similar fashion. With the method used here you can actually build any unit in the same or less time than it takes to design and etch a printed circuit board. (One main advantage of etched boards, however, is saving time on successive boards — but since I seldom build more than one of any particular project, PC boards are not time-effective for me.)

I use epoxy material punched with holes on a 0.1-

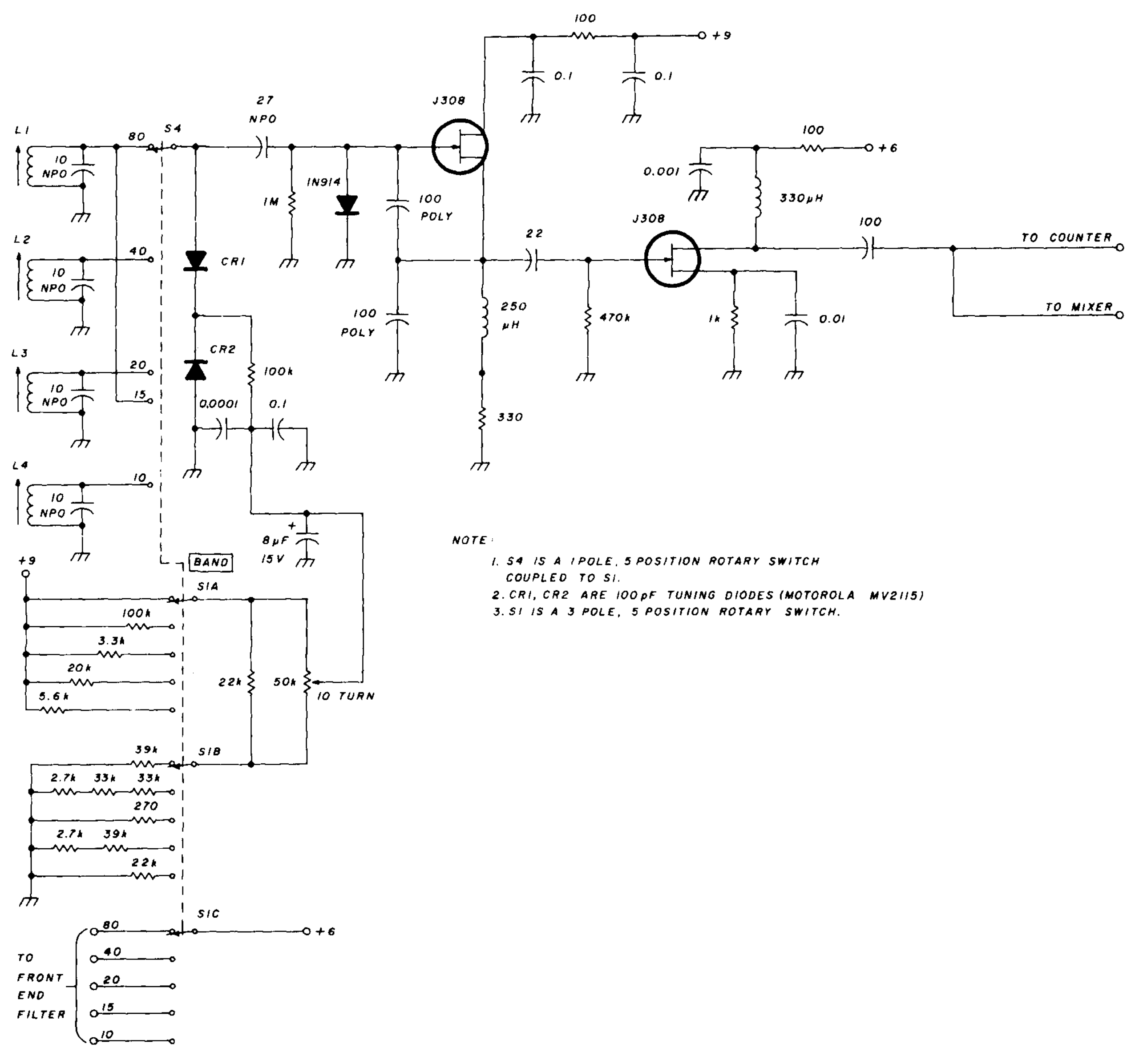
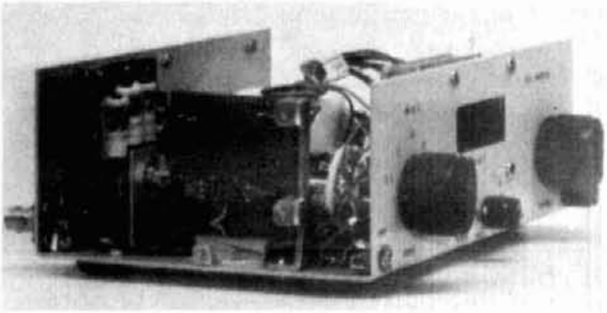


fig. 1. VFO schematic.

table 1. VFO coil data.

coil number	band	turns on 1/4" form*	frequency range (MHz)	wire No.
L1	80	21	12.5-13.0	26
L2	40	15	16.0-16.5	26
L3	20	48	5.0- 5.5	32
L1	15		12.0-12.5	
L4	10	10	19.0-20.0	22

*Coil forms Millen 69043 used but any good 1/4-inch (0.635 cm) ceramic form should be suitable.



Left side view shows bandswitch and ganged VFO switch. Vertical board in center is BFO; VFO board and coils are mounted vertically against rear panel.

inch grid and clad with copper on one side, widely available from mail order suppliers.* Insulated circular pads for IC pins and other components are cut with a pad cutter tool,* either by hand or with the tool in a drill.

For the VFO I disassembled a single-pole, six-position rotary switch and mounted a 3-inch (7.6 cm) square piece of the epoxy material between the switch wafer itself and the switch index mechanism. Three holes were drilled in the material: one for the switch shaft and two that coincide with the wafer mounting screws on the switch itself. (You may have to obtain mounting screws a little longer than those that come with the switch to allow for the 1/16 inch (0.16 cm) thickness of the copper clad board.)

Next cut appropriate pads for the coils and the VFO circuitry. Use T-44 push-in pins,* for terminals such as transistor connections and all input and output connections. The four coils are mounted on the front (non copper-clad) side of the board by passing their leads through and soldering to the pads on the other side which directly connect to the switch. The coil bodies are then covered with clear Silicone II, an adhesive that bonds them firmly to the board and prevents any movement of either the coil bodies or the windings on the coils. This is extremely important in that it is a significant factor in the frequency stability of the VFO. All wiring on the VFO should be direct and rigid, especially the jumper on the switch for the 80-meter position. Sound VHF wiring practices should be followed.

VFO adjustment

After wiring is completed, a test jig should be assembled as indicated to determine the values of the series voltage-dropping resistors necessary to have the tuning control, a 10 turn, 50 kilohm potentiometer, cover the desired range of frequencies (see **fig. 2**).

VFO adjustment proceeds as follows:

- Connect a frequency counter to the VFO output.

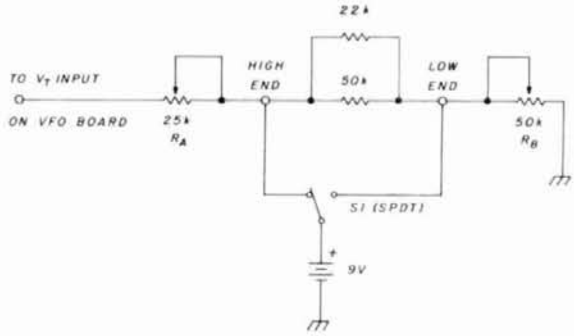
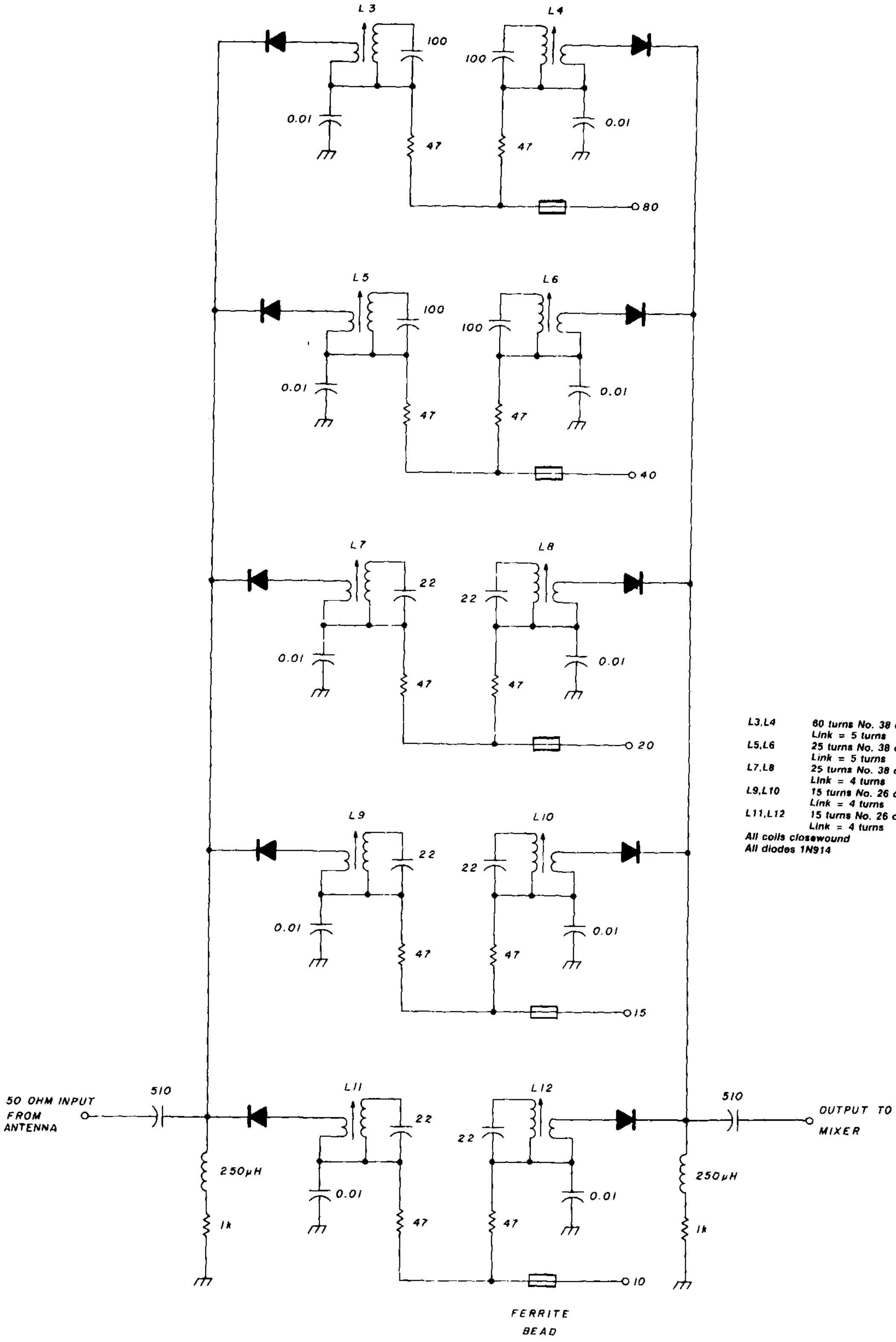


fig. 2. Test jig for determining the tuning voltage divider series resistors for each band.

- Set the VFO to the 10 meter position.
- Set S1 on the test jig to the *HI* position (at end of potentiometer R_A).
- Adjust R_A so that the VFO frequency is about 10 kHz above the upper limit wanted — for example, on 80 meters set R_A so that the VFO output is 13.010 MHz.
- Put S1 in the *LO* position at the end of R_B.
- Adjust R_B until the VFO output is about 10 kHz below the lower limit wanted — for example, on 80 meters set R_B so that the VFO output is 12.49 MHz.
- Put S1 back to the *HI* position and recheck the frequency. Since these settings interact it may be necessary to repeat the procedure. Measure the values of R_A and R_B and use fixed resistors of those values on the bandswitch.
- Repeat this procedure for the remaining band positions on the VFO. It may be necessary to adjust the coil slugs to obtain the required range. On 40 meters it may be necessary to place an approximately 68 kilohm resistor in series with the 9-volt source and R_A.

Because it's unlikely that your unit will require the

*All items marked with an asterisk are manufactured by Vector, Inc.



L3,L4	60 turns No. 38 on 1/4-inch diameter Link = 5 turns
L5,L6	25 turns No. 38 on 1/4-inch diameter Link = 5 turns
L7,L8	25 turns No. 38 on 1/4-inch diameter Link = 4 turns
L9,L10	15 turns No. 26 on 1/4-inch diameter Link = 4 turns
L11,L12	15 turns No. 26 on 1/4-inch diameter Link = 4 turns

All coils closewound
All diodes 1N914

fig. 3. Bandpass filter schematic.

same values of series resistors as mine because of differences that will occur in many components, I advise going through the procedure. I also recommend using alkaline batteries for both 6 and 9-volt supplies. Because of other connections to the 9-volt supply, six AA cells are used; the 6-volt supply consists of four D cells.

bandpass filters

These components are enclosed in a separate unit made entirely of copper-clad punched board. The two coils for each band are placed next to each other on 1/4-inch (0.635 cm) centers. Six volts applied to a band terminal forward biases the respective diodes and allows signals from the antenna to pass through the resonant circuit. The use of diodes, while drawing additional current, significantly reduces the mechanical problems associated with rotary switches.

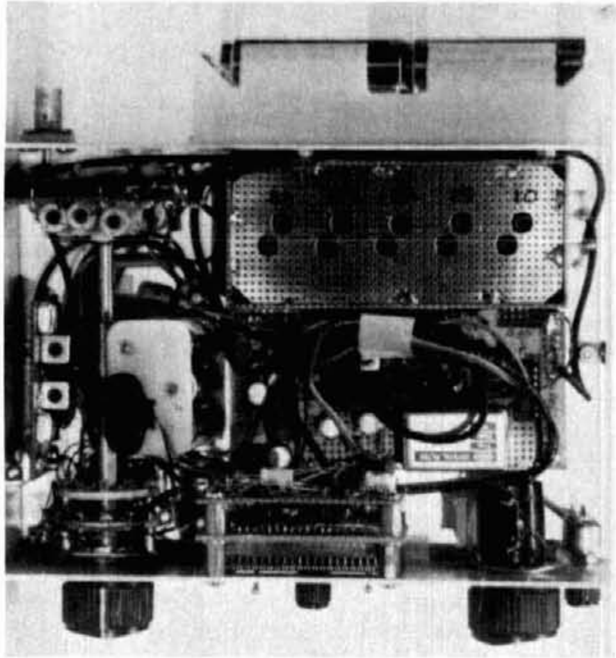
Adjustment proceeds in the following order:

- Connect an antenna to the input and a receiver to the output.
- Set the receiver to 80 meters.
- Apply 6 volts DC to the 80-meter terminal.
- Set the receiver frequency 1/4 of the way up from the bottom of the band, at approximately 3.625 MHz.
- Adjust one of the 80-meter bandpass coils for maximum received signal (or noise).
- Move the receiver to a frequency 1/4 of the way down from the top end of the band, at approximately 3.875 MHz.
- Adjust the other 80-meter bandpass coil for maximum response.
- Repeat as necessary to compensate for interaction.
- Do the same for the remaining four bands.

These settings will establish filter response across the entire bands. If you're primarily interested in either SSB or CW, the coils can be peaked accordingly. If you don't have a receiver or cannot borrow one, it's possible to peak the bandpass filters with the receiver itself, once completed.

BFO

This unit is constructed on a separate board but could be placed on the IF board. Using an available crystal filter translated to a USB BFO frequency of 9.000 MHz and an LSB BFO frequency of 9.0030 MHz (see **fig. 3**). Normal (i.e., non-inverted) sideband in this receiver uses the 9.000 MHz BFO crystal, so no readout offset is necessary. In the reverse sideband position the readout will be off by 3 kHz. The BFO circuit uses series resonant crystals. L1 and L2 are 10.7 MHz IF transformer primary windings (4 μH) with the



Top view shows bandpass filter (top left), IF strip (top center); VFO board (bottom left), BFO board (bottom center); and counter boards (right center). 6-volt battery pack is mounted at rear.

resonating capacitor removed. The 260 and 220 pF capacitors are polystyrene and the 100 pF capacitors are silver mica. To adjust, connect a counter to the output and apply 6 volts DC to the BFO oscillator desired. Adjust the corresponding series inductance for the correct output frequency.

IF board

This board contains the double-balanced mixer, crystal filter, IF amplifier, and audio stages (see **fig. 4**). The only adjustment here is to peak the slug in T1 for maximum signal. T1 is also a 10.7 MHz IF transformer with an external capacitor to bring it down to 9.0 MHz. RF derived AGC is internally generated in the Plessey SL6700 IC. U4 is a Texas Instruments TL442 double-balanced mixer. Connection of pins 3 and 12 result in a 500-ohm output impedance to match the crystal filter. If your filter has a different input impedance you may have to design an appropriate matching network. Application of 9 volts to the mixer is necessary to achieve adequate gain. U6 is an audio preamp and U7 provides up to a quarter watt of audio output to an 8-ohm speaker or headphones. The SL6700 has a maximum voltage rating of 7 volts.

frequency counter

This unit uses LCD and CMOS components because both draw little current and also because we need to count frequencies up to 20 MHz (see **fig. 5**). The least

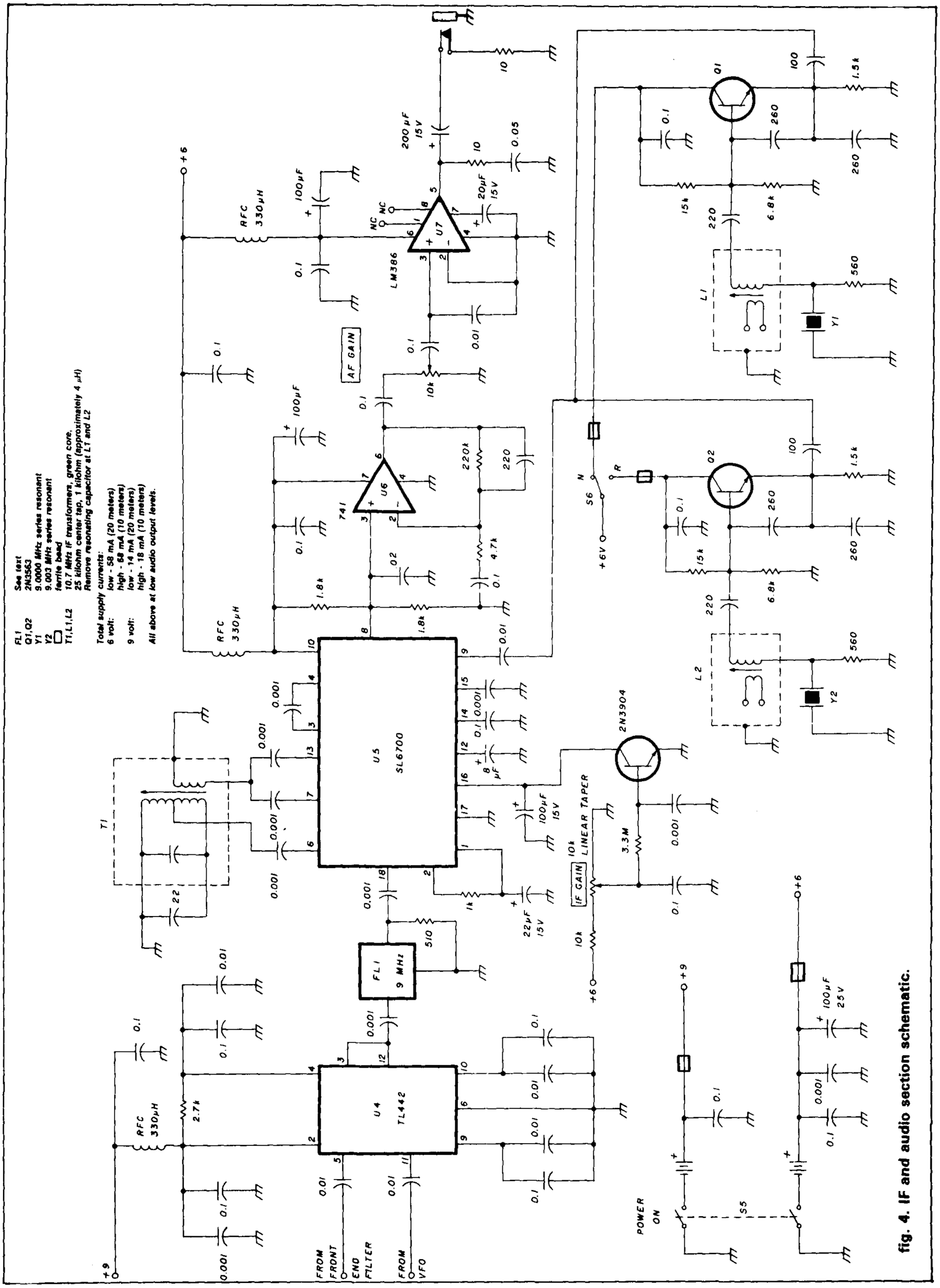
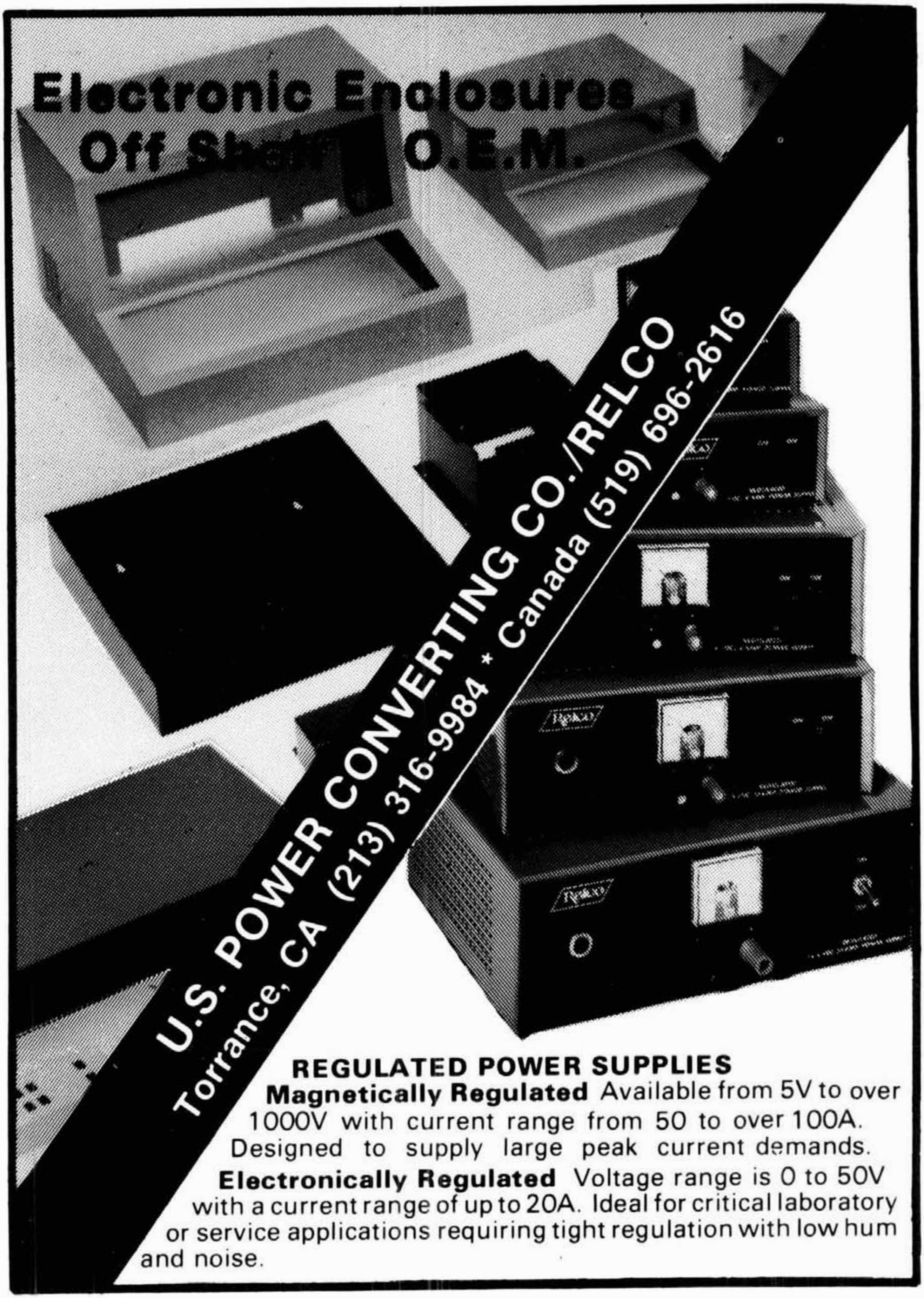


fig. 4. IF and audio section schematic.



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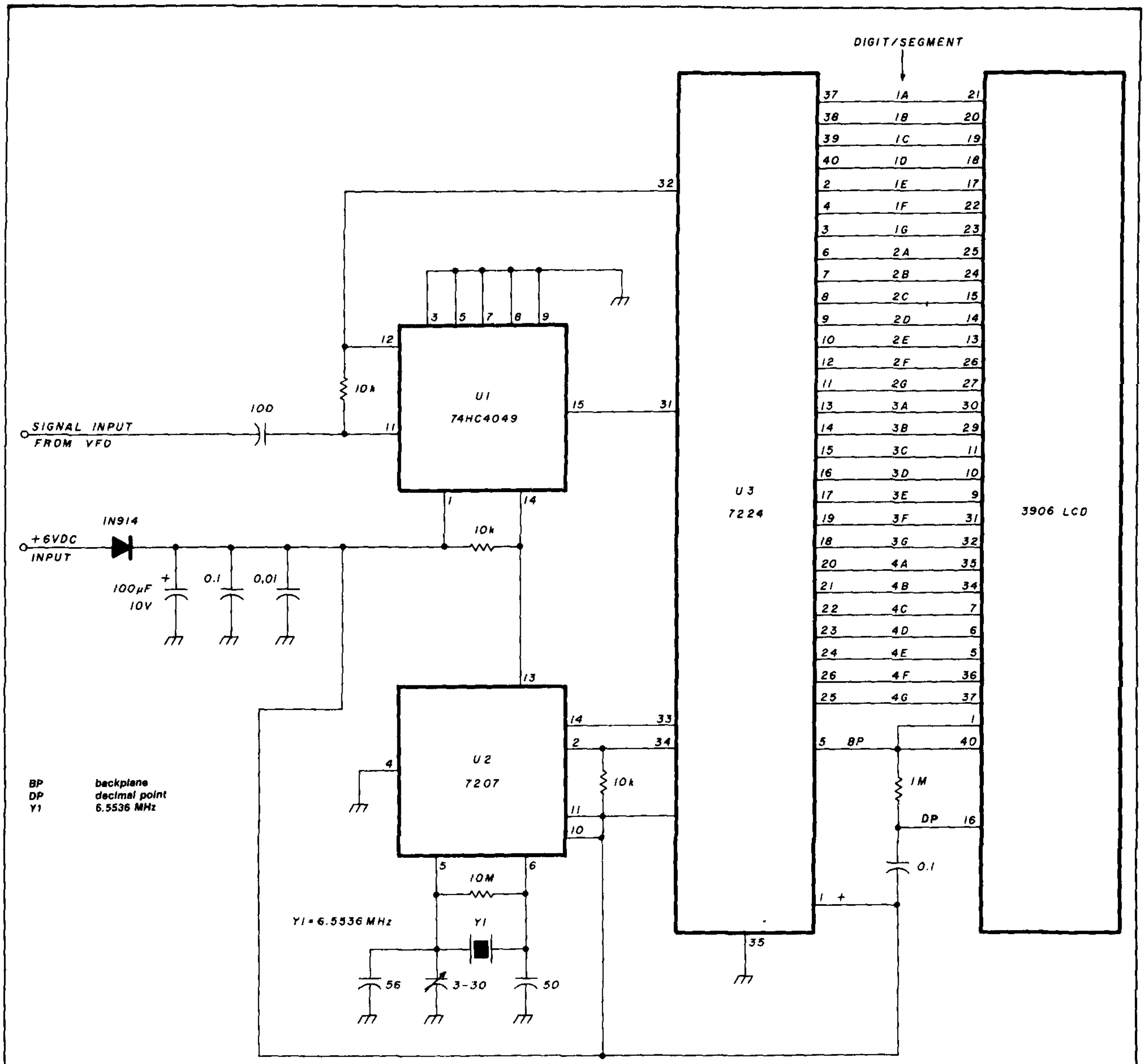

fig. 5. Frequency counter schematic.

significant digit reads out in hundreds of Hertz because of a 10 millisecond gate provided by U2 and its associated crystal. This, and the counter chip, U3, are Intersil ICs. (It's important to note that Intersil also manufactures a 7207 ***A***. It's only through the use of the 7207 — without the "A" — and the specified crystal frequency that the 10 millisecond gate time can be obtained, so be careful when ordering.)

Note that U1 is a high-speed version of the CMOS type 4049. Because the latter type will not function up to 20 MHz, the 74HC4049 is used instead.

The liquid crystal display is a Hamlin type 3906. It's a little tricky to identify pin 1; to do so just hold the display in front of you and move it so that light reflects off its face. You'll notice the outlines of the 8s that are the digits. Look for the three decimal points between the 8s. Rotate the display if necessary so that the decimal points are at the bottom. The left end pin on the top row is pin 1. These both connect to the display backplane (see **table 2**).

The counter is constructed on two pieces of perforated board 2-1/2 inches (6.35 cm) square, separated from each other and the receiver front panel by 1/2 inch (1.27 cm) threaded metal standoffs at each corner. The socket for the 7224 IC is a low profile type and is nested inside the socket strips for the LCD. These strips are merely the halves of a 40-pin IC socket separated by cutting it lengthwise with a hacksaw.

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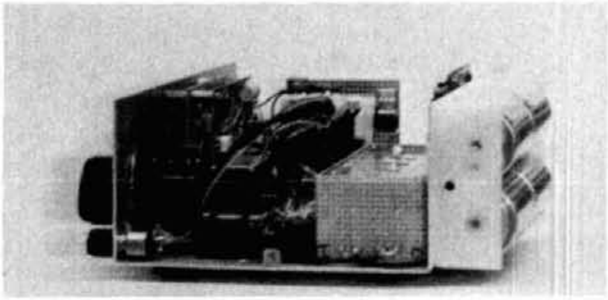

Right side view shows tuning pot and IF gain pot.

table 2. 3906 and 7224 designations.

3906 pins				7224 pins			
20	1B	1A	21	20	4A	4B	21
19	1C	1F	22	19	3F	4C	22
18	1D	1G	23	18	3G	4D	23
17	1E	2B	24	17	3E	4E	24
16	DP *	2A	25	16	3D	4G	25
15	2C	2F	26	15	3C	4F	26
14	2D	2G	27	14	3B	1/2 digit	27
13	2E		28	13	3A	CO	28
12		3B	29	12	2F	LZ1	29
11	3C	3A	30	11	2G	LZO	30
10	3D	3F	31	10	2E	C inhibit	31
9	3E	3G	32	9	2D	count in	32
8	4DP		33	8	2C	RST	33
7	4C	4B	34	7	2B	ST	34
6	4D	4A	35	6	2A	ground	35
5	4E	4F	36	5	BP	OSC	36
4		4G	37	4	1F	1A	37
3			38	3	1G	1B	38
2			39	2	1E	1C	39
1	BP	BP	40	1	+	1D	40

*Use this decimal point

These two sockets are mounted on unclad perfboard. The rear board is copper clad and contains the signal processing and gating ICs, U1, and U2. Because of the relatively high frequencies involved, this board *must* be copper clad.

Upon completion of the counter wiring connect a clip lead between pin 29 on U3 and ground. For test purposes this will cause all digits to appear as zeros with no signal input. Connect the 6 volts to the counter; application of voltage greater than 6.5 to U3 could destroy the IC. The purpose of the 1N914 in the counter is to reduce the 6 volts slightly. Four zeros should appear on the display with a decimal point between the least significant zero and the next one.

To calibrate the counter, run a short length of RG-174/U coax from the output of the BFO to the counter input. Connect an external frequency counter to the same point. Adjust the 30 pF trimmer capacitor at U2 until the last four digits of the two counters are the same. Remove the clip lead from the 7224. Leading zeros will now be blanked on the display.

general construction notes

The receiver is built in an aluminum enclosure available from Radio Shack (see **table 3**). A slightly larger box would have allowed placement of the batteries inside. The band switch is a three-pole, six-position rotary mounted on the front panel. A coupling joins the end of its shaft to the VFO switch shaft. The 9-volt battery pack is attached to the chassis bottom with self-adhesive Velcro strips from Radio Shack. This sturdy arrangement allows easy removal for battery replacement. Four D cells in a holder mounted on the outside rear wall of the receiver supply 6 volts. A jack on the front panel provides audio for external speaker or headphones. All circuits and functional modules are extensively decoupled with ferrite beads and capacitive bypassing. The receiver has no birdies and the decoupling is probably a significant factor. Small diameter RG-174/U coax is used for all signal interconnections as well as to and from the volume control. The only totally shielded unit is the bandpass filter unit. The IF gain control carries DC and does not require shielding.

changes

Few designs remain unchanged for long. Were I to build this one again, I would consider making some

table 3. Parts and source list.

part	source
Hamlin 3906 LCD, MV2115 diodes, 74HC4049, J308, 741, LM386, 10.7 MHz IF transformers, Vector board	Circuit Specialists PO Box 3047 Scottsdale, Arizona 85267
Intersil 7224 counter IC	Jameco Electronics 1355 Shoreway Road Belmont, California 94002
6.5536 MHz crystal	Digi-Key Corp. 701 Brooks Avenue South Thief River Falls, Minnesota 56701
Intersil ICM7207 IC	Advanced Computer Products PO Box 17329 Irvine, California 92713-7329
Texas Instruments TL442 IC	Radiokit PO Box 411 Greenville, New Hampshire 03048
Plessey SL6700 IC	Circuit Board Specialists PO Box 969 Pueblo, Colorado 81002
BFO crystals	JAN Crystals 2400 Crystal Drive PO Box 06017 Fort Myers, Florida 33906-6017
Enclosure, battery holders, miscellaneous parts	Radio Shack

changes. First, this receiver is designed with VFO frequencies chosen so that, for conventional SSB practices, a 9 MHz USB filter and one BFO oscillator and crystal would probably be adequate for most users. Given the current drawn from the D cells, the batteries will probably last their shelf life; it may be possible to change to C cells to save weight and volume. Perhaps the two sets of batteries could be changed to one set of eight C cells with a voltage regulator for the 9 volts and a direct tap for the 6 volts. One change I would definitely make would be separate 80 and 15 meter VFO coils. This would make it much easier to set the required frequency range on both bands.

Other than the 10 pF NPO capacitors across each VFO coil, no further temperature compensation was done since stability at that point was adequate for my purposes. VFO stability could be further enhanced, especially at the higher VFO frequencies. I would also build the VFO in a separate, shielded enclosure, because there is a slight frequency shift when the receiver cover is removed. This small portable receiver meets all my original goals: simplicity, low cost, and good performance. These are exactly the characteristics which make this receiver ideal for newcomer and old-timer alike.

I'll be happy to respond to any questions accompanied by an SASE. (Send to Author's address —Ed.).

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high dynamic range on 2 meters

In last November's VHF/UHF World column[1] we discussed high dynamic-range (HDR) with emphasis on circuitry for the 6-meter band. Judging from the correspondence I've received and the quantity of parts ordered from Proto Parts,* the interest in this subject is quite high. There were also plenty of inquiries for information about a companion 2-meter down-converter.

Further work has been conducted since reference 1 was published. Much of this new work, which primarily dealt with antenna pattern improvements, local oscillator phase noise studies and problems with the IF or receiver, was presented at the Dayton Hamvention.[2]

*Proto-Parts (formerly Proto Fab), 74 Wedgemere Drive, Lowell, Massachusetts 01852.

Since time is precious, I'll keep this month's column short and to the point, concentrating almost entirely on the design of a 2-meter HDR receiver down-converter as shown in block form in **fig. 1**. The material in reference 1 will not be repeated except as required. Further information on this very interesting subject will be published as time permits.

preamplifiers

Let's start by assuming that you've read references 1 and 2. Let's go directly to the preamplifier stage. Common semiconductor devices used on 2-meter preamplifiers include bipolar transistors, JFETs, dual-gate MOS FETs and GaAs FETs. All of these can attain excellent noise figures (less than 2 dB) and more than sufficient gain (12 to 30 dB!).

High gain is not too compatible with high dynamic range since the higher the gain, the more likelihood of compression, overload, and IMD (intermodulation distortion). Furthermore, overdriving the mixer, which results in a lower dynamic range, can result from too much gain in the stage preceeding the mixer.[1]

The HDR transformer-coupled lossless feedback preamplifier described in reference 1 can be used as shown to cover the entire frequency range from 1.5 to 200 MHz with almost no loss of dynamic range and only a slight increase (0.5 to 1.0 dB) in noise figure at the higher end of this frequency range. Hence this circuit is highly recommended for a 2-meter HDR preamplifier. However, it requires proper input and output filtering similar to the scheme shown on the 6-meter converter to prevent responding to the entire HF/VHF spectrum! (More on this shortly.)

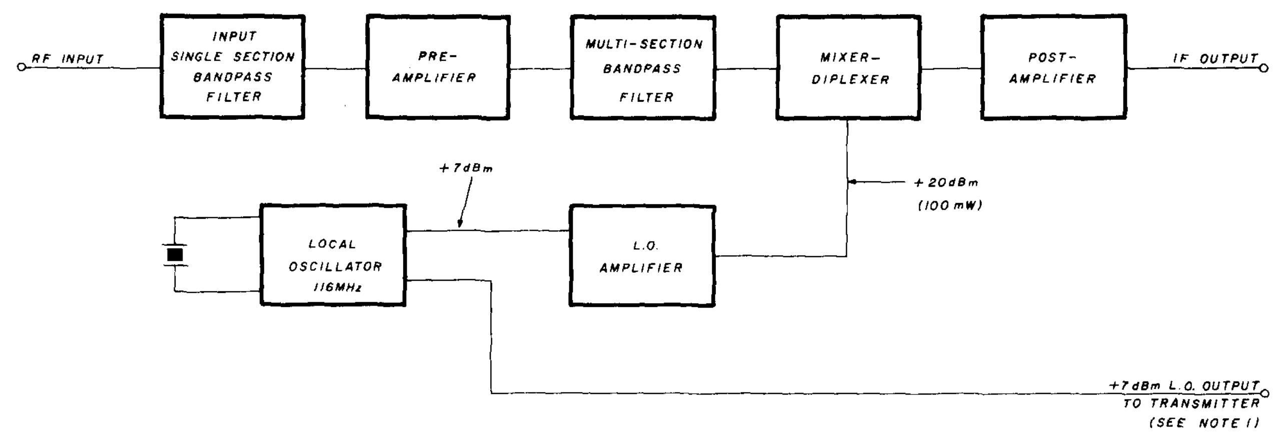


fig. 1. Overall block diagram of a 2-meter HDR receive-type down converter. ***Note 1*****: If the transmitter LO port is unused, terminate it with a 50-ohm load.**

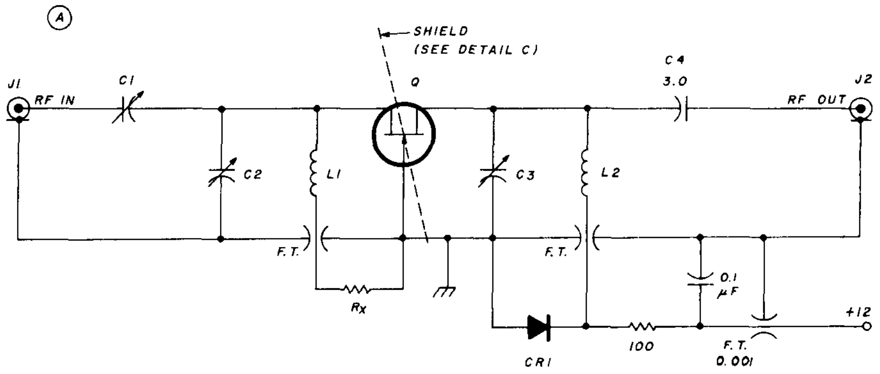
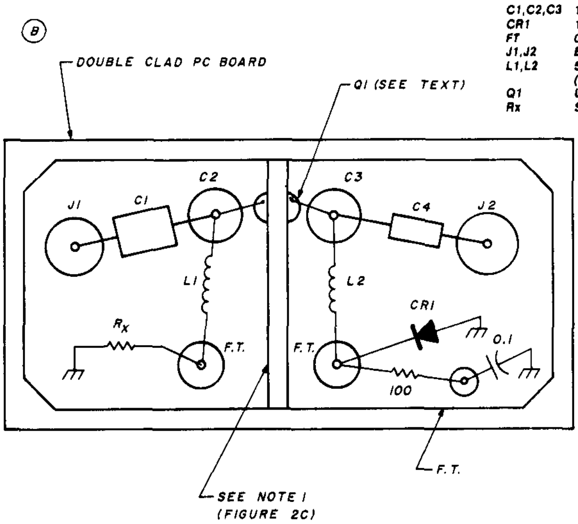


fig. 2A. Schematic diagram for a recommended JFET 2-meter preamplifier with moderate dynamic range. Gain is 11 dB and noise figure is 1.5 to 2 dB typical.



C1,C2,C3	1-10 pF low-loss air variables
CR1	1N4001 or equivalent "idiot diode"
FT	0.001 μF feedthrough type capacitor
J1,J2	BNC connectors
L1,L2	5 turns of No. 18 AWG on 0.25 inch (6.35 mm) ID and 0.5 inch (12.7 mm) long
Q1	U310 JFET (see text)
Rx	Set for I_D of 10 ± 2 mA (150 ohms typical)

fig. 2B. Bottom view of preamplifier showing recommended construction technique. The preamplifier can be built on the cover of a Pomona 2417, Bud CU123, or equivalent cast box. (See text for other details.)

Dual-gate MOSFETs — and GaAs FETs as well — are not recommended for HDR since they have too much gain. Both are excellent for very low noise figures. The output compression point for GaAs FETS is poor for HDR (+6 to +8 dBm or 4 to 6.3 milliwatts).[3] If you use them they should have built-in bypass relays so they can be switched out of the circuit if there are strong signals present that limit the dynamic range.

One of my favorite quick-and-dirty preamplifiers uses a JFET. I particularly like the U310, a low-cost, readily available JFET. *Caution: don't use the J310, a plastic TO-92 version of this device, above 100 MHz. The plastic package has too much internal inductance in the gate lead and the device will be potentially unstable at 2 meters and above.*

The U310 can deliver good performance from 50-450 MHz with a typical gain of 11 to 13 dB, a reasonable noise figure (1.5 to 3 dB), and very good dynamic range. The typical output compression point is not as high as the HDR lossless feedback circuit and is typically in the range of +10 to +14 dBm (10 to 25 milliwatts), which is more than sufficient for most applications.

A JFET preamplifier offers another advantage in that it has some "built-in" selectivity from its associated matching circuits so it can be operated without additional input or output filtering. Two of these amplifier circuits in cascade will usually have more than adequate selectivity to do the job as is. The circuit I use has been around many years and was discussed in reference 4. The recommended circuit and values for 2 meters are shown in **fig. 2**.

If you don't want to build all the extra filtering associated with the bipolar lossless feedback circuit and can sacrifice a small amount of dynamic range, you can use the JFET circuit shown in **fig. 2**. If only a single stage is used, the overall noise figure of the converter will be approximately 4 dB, hardly a problem for most types of operation. This sure beats many commercial transceivers that usually have a 7-10 dB or higher noise figure along with poor dynamic range and phase noise to boot! Two JFET preamplifier stages can be cascaded for moderate

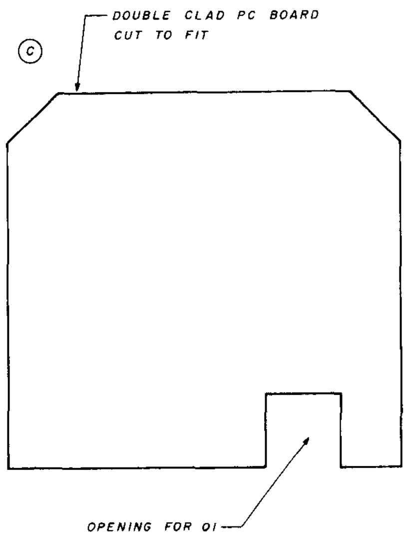


fig. 2C. Typical shield to be placed across Q1. *Note 1*: Solder both sides of shield to the ground plane where shown.

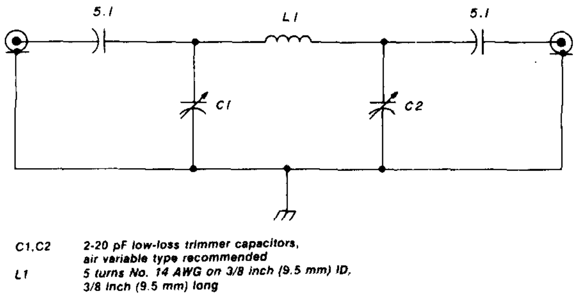


fig. 3. Typical recommended input band-pass filter.

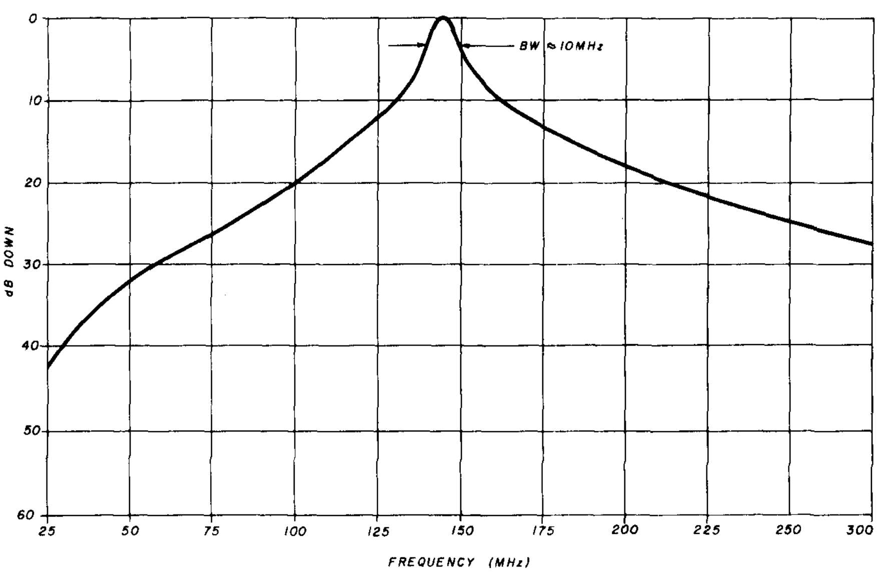


fig. 4. Frequency response of the simple band-pass filter shown in *fig. 3*.

noise figure (1.5-2 dB) with a commensurate loss in dynamic range.

input filters

If the HDR lossless feedback preamplifier is used, input and output filtering are required. A simple single section bandpass should be used on the input for reasons discussed in reference 1. Typically speaking, the capacitance-coupled circuit in reference 1 has a sort of high-pass type of bandpass response,[5] so it is not as effective with all the many types of high power RF emitters that are active on both sides of the 2-meter band.

Figure 3 shows an interesting filter topology.[6] At first glance it looks like a Pi-network. It has one more component than the usual filter, a second tuning capacitor.

The advantage of this filter topology is that it has a symmetrical response about the center frequency with only a moderate loss, 0.3 to 0.5 dB typical. As shown in **fig. 4**, the half-power bandwidth is 10 MHz, while the 10 dB and 20 dB down bandwidths are about 30 and 110 MHz, respectively.

band-pass filters

Again, if a broadband preamplifier is used, additional filtering will be required just ahead of the mixer as discussed in reference 1. A recommended three-section band-pass filter is shown in **fig. 5**. A plot of its filter characteristics is shown in **fig. 6**. It has a fairly symmetrical passband shape and only a moderate loss — 1.3 to 1.5 dB. Typical half-power bandwidth is 10 MHz, and the 10 and 30 dB down bandwidths are typically 15 and 33 MHz, respectively.

The loss in this band-pass filter will not degrade noise figure significantly if it is preceded by at least 9 to 10 dB of preamplifier gain. This filter should provide more than adequate selectivity for a high performance 2-meter receiving converter.

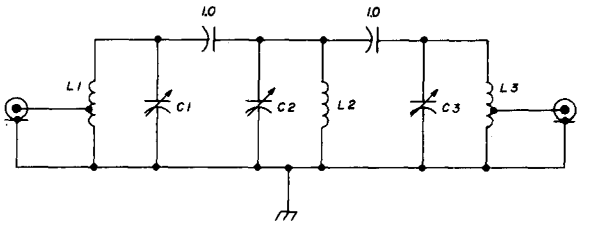
mixers

Various types of mixers were discussed in reference 1. The double balanced mixer (DBM) is highly recommended. The MiniCircuits Labs TAK-1H or equivalent is highly recommended for 2 meters. Other mixers, shown in **table 1** of reference 1, are also acceptable. The lower drive DBMs such as the SRA-1 will reduce dynamic range but still may be more than sufficient for most applications.

The DBM circuit in reference 1 is very wideband and already covers frequencies through 500 MHz so it will not be duplicated here. *Don't leave out the diplexer*; it's *very* necessary. Also, since the 2-meter band is much higher in frequency, the use of a 14-MHz IF is discouraged since it won't offer sufficient image rejection without extensive filtering.

local oscillator

A Colpitts series-mode oscillator similar to the one discussed in references 1 and 7 is highly recommended. Since the typical IF for a 2-meter converter is 28-30 MHz, a 116-MHz local oscillator is recommended. *Don't use a 58-MHz oscillator with a frequency doubler; it will make breakthrough from TV and FM stations a potential problem. Don't be "penny wise and pound foolish." Remember — this is*



C1,C2,C3 2-20 pF trimmer capacitors
L1,L3 4 turns No. 20 AWG 0.25 inch (6.35 mm) ID and 0.5 inch (12.7 mm) long. Tap is placed 1 turn up from ground end
L2 Same as L1 without tap

fig. 5. Typical recommended three-section 2-meter band-pass filter.

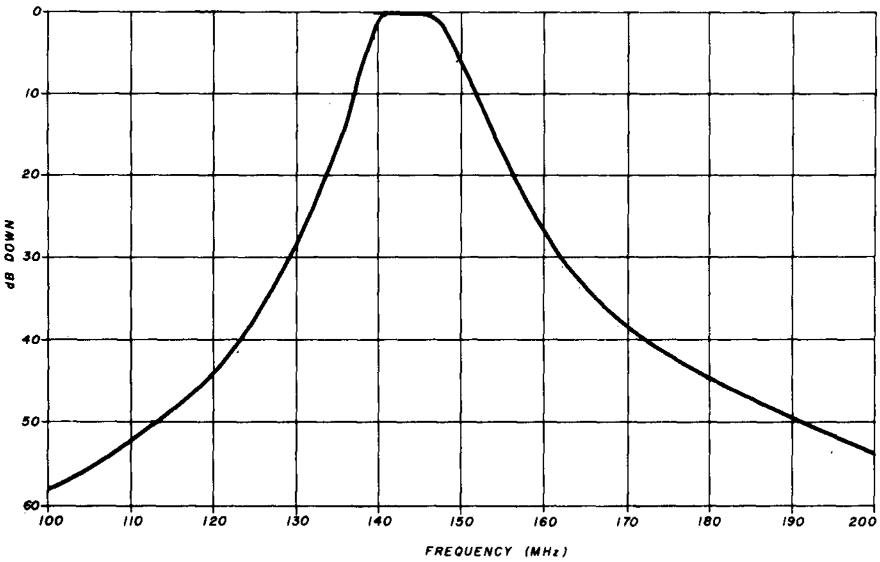


fig. 6. Plot of the frequency response of the three-section 2-meter band-pass filter shown in *fig. 5*.

a high-performance HDR receiving converter!

Since the frequency of the oscillator is much higher than in the 6-meter converter, the tuned components had to be modified. The final oscillator circuit and a suitable power amplifier are shown in **figs. 7** and **8**. It will provide the necessary 100 milliwatts of power. (More on this later.) Again, a low-level output is provided for a transmitting up-converter.[8]

postamplifiers

The low-noise postamplifier using the lossless feedback circuit described in reference 1 is recommended without changes, so it won't be duplicated here. Note how the modular approach discussed in references 1 and 7 has paid off. If you have the mixer and post-amplifier from the 6-meter converter, all you have to do is to change the local oscillator and front end, and away you go on 2 meters.

construction tips

Once again, the modular approach is recommended, with each separate circuit packaged in a shielded box. The circuits can be built above a double-clad printed circuit type of material as described in reference 1. The boards can be attached to the cover of the boxes with the connectors. This method provides excellent grounding, and the components can be soldered directly to the board where grounding is required.

The three-section band-pass filter must be carefully laid out so that mutual coupling will not cause passband ripple. This can be accomplished *if the individual coils are all wound in the same direction and placed at least 1/2 inch (12.7 mm) apart.*

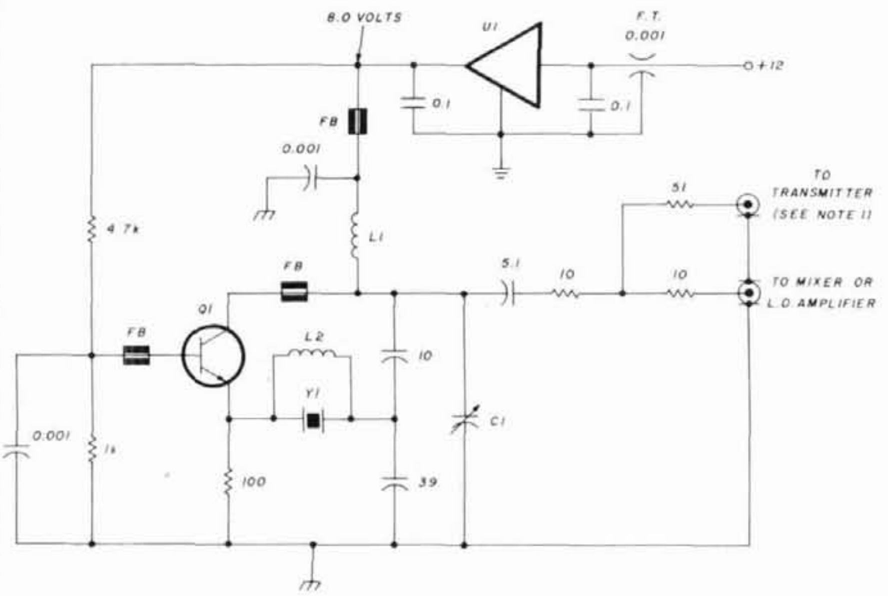
The U310 preamplifier circuit, if used, should be carefully laid out with shielding in mind. First a hole should be drilled near one side of the center of the circuit through the PC board. Its diameter should be 0.191 inches (4.85 mm), the diameter of a No. 11 drill. Next, place the U310 in the hole upside down and quickly solder the gate lead to ground as well as the tab on the U310 can. This provides additional input to output isolation. Next place a shield with a notch for the transistor leads across the JFET to isolate the input and output circuits as shown in **fig. 2**.

Leads in the oscillator should be kept short, especially those going to the crystal and its associated components. Also, it's wise to place the oscillator in a box separate from the LO amplifier so that any heat generated by the amplifier will not affect the stability of the oscillator. This has a secondary benefit: if the oscillator is separate, it can be used directly with a standard (+5 dBm or 7 milliwatt) DBM until you upgrade to the high-level DBM.

tune-up

First connect all the modules together as a full converter per **fig. 1**. Then connect an appropriate 2-meter antenna to the input of the converter. If the oscillator is functioning, noise and possibly signals will be heard.

The local oscillator should be tuned for maximum output as indicated on an RF power meter. *Don't detune the oscillator for frequency "netting"; this*



C1	1-10 pF low-loss trimmer capacitor
FB	ferrite bead (Ferroxcube 56 590 65/3B or equivalent)
U1	78L08 8-volt three-terminal voltage regulator
L1	8 turns No. 24 AWG enameled wire close wound on a 0.1 inch (2.5 mm) ID
L2	0.39 μH RF choke or 10 turns of No. 28 AWG enameled wire on a T-25-6 toroid
Q1	2N5179, NE73432B, or equivalent transmitter
Y1	5th overtone series mode 116 MHz crystal in HC18/u wire leaded holder

fig. 7. Recommended oscillator circuit for a 2-meter HDR receive converter. The values shown are for 116 MHz and can be used over a wide range of frequencies. If an oscillator is desired over a larger range (perhaps ±25 MHz) the coil, L1, can be increased or decreased slightly to obtain resonance.

will decrease frequency stability. If only a diode detector is available, place a 3 to 10-dB attenuator pad on the output of the oscillator and the diode detector on the output of the pad. Tune the oscillator for maximum output power.

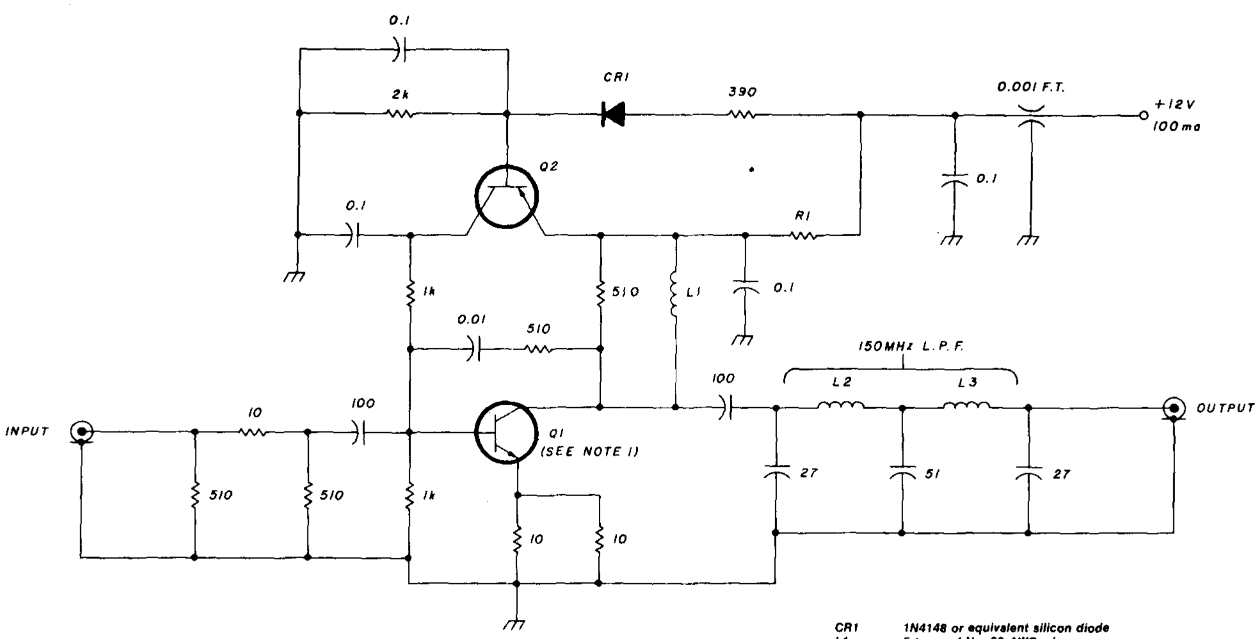
If a normal range DBM is used, connect the LO directly to the DBM. If an HDR DBM is used, connect the LO to the LO amplifier with a piece of coaxial cable and measure the available output power. It is not critical, but should be between 50 to 150 milliwatts for the HDR mixer configuration.

If the lossless feedback preamplifier is used, it doesn't require tuning but the input and bandpass filters do. The input filter can be peaked on a weak signal or tuned for minimum VSWR on a low-power test set-up. The bandpass filter is best tuned on a sweep set-up, but again could be tuned for maximum signal strength without a great loss in performance.

If the U310 preamplifier is used, first set the input capacitor for nearly minimum capacitance. Next peak the output capacitor for maximum gain or noise when in a typical circuit. The typical gain should be 11 to 12 dB. If noise figure measurement gear is available, tune the input circuit for the best noise figure. Sometimes this can be done at local VHF/UHF conferences, especially when noise figure measurement contests are conducted.

performance

At first, performance may not seem spectacular. In fact, the gain may seem low despite the noise figure available. If you can borrow a noise figure meter, check the performance so you'll know you're where you should be. You should be able to hear just



CR1	1N4148 or equivalent silicon diode
L1	5 turns of No. 20 AWG wire on 0.25 inch (6.35 mm) ID and o.5 inch (12.7 mm) long
L2,L3	7 turns of No. 24 AWG 0.1 inch (2.5 mm) ID and 0.25 inch (6.35 mm) long
Q1	CATV type of stud-mounted medium power transistor. See reference 8. MSC 82091, Acrian CD1899, NEC74020/2SC1251, SSM SD 1005 or TRW LT2001 are all suitable types
Q2	high gain PNP transistor. 2N2905 or equivalent
R1	20 ohms 0.5 watts. Can use two 39 ohm 1/4 watters in parallel

fig. 8. Recommended local oscillator amplifier for use with high-level DBM. *Note 1*: Bolt Q1 stud to cover of box to provide better heatsinking.

about anyone who's working into your area, if your antenna gain is sufficient.

In the presence of strong signals, you will immediately notice the improved performance. Now you'll see why I've previously stressed that the IF will ultimately be the limiting device! If you used the modular approach, the circuits can be swapped at will as you step up in performance. Also, should you ever suffer a failure, repair or bypassing is easily accomplished. It may even be smart to incorporate a bypass switching arrangement to switch out the IF postamplifier when high level signals are present.

summary

This month's column again stressed improved performance that is within the means and skill level of most Amateurs. Those who have tried these approaches have been pleasantly surprised. It's nice to know that you're keeping up with the state-of-the-art! When good gear is used, contacts are more enjoyable and the weak ones are easier to work.

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important VHF/UHF events

November 2:	*Peak of Taurids Meteor Shower predicted at 0930 UTC*
November 2-3:	*ARRL International EME Contest*
November 3:	*Peak of Casseopids Meteor Shower predicted at 0930 UTC*
November 12:	*EME Perigee*
November 17:	*Peak of Leonids Meteor Shower predicted at 0300 UTC*
November 23-23:	*ARRL International EME Contest*
December 2:	*7-11 PM Local, 2-meter SWOT Contest (contact K5IS for details)*
December 11:	*EME Perigee*
December 13:	*Peak of Geminids Meteor Shower predicted at 0650 UTC*
December 21:	*Peak of Ursids Meteor Shower predicted at 2200 UTC*
December 21:	*± 1 month, winter peak of sporadic-E propagation*

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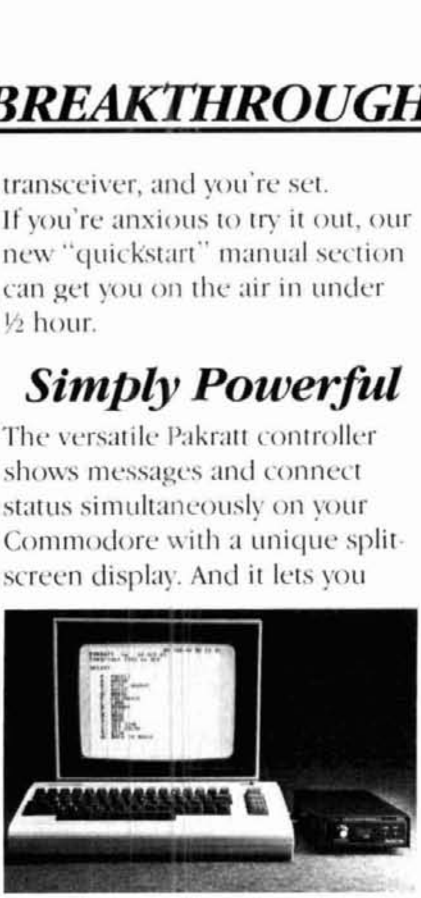

PK-64 shown with HF modem option. Computer not included.

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ham radio TECHNIQUES

the mystery of the tapered element

I received an interesting letter in the mail the other day. It seemed some of the DXers were having a lively discussion on the effects of taper on the elements of a Yagi beam antenna. Recently published information on tapered elements seemed to indicate that a severely tapered element could actually be longer than a half-wavelength yet still be resonant.[1]

The letter writer concluded that it was reasonable to see that a "thick" element is shorter than a "thin" element, but it was beyond the realm of possibility that a tapered element could be longer than either a "thin" or "thick" element.

My friendly inquirer closed his letter by saying that a "longer-than-normal resonant element of the tapered variety contradicts the laws of Nature. Say *it isn't so!*"

the background

This was an interesting letter. *Is* it possible to have a tapered element physically longer than a half-wavelength at a given frequency, yet resonant at that frequency? A little insight into basic antenna theory might provide the answer. To quote the *ARRL Antenna Handbook:*[2]

The shortest length of wire that will resonate to a given frequency is one just long enough to permit an electric charge to travel from one end to the other and then back again in the time of one RF cycle. If the speed at which the charge travels is equal to the velocity of light, 300,000,000 meters per second, the distance it will cover in one cycle will be equal to this velocity divided by the frequency in cycles per second, or

$$\lambda = \frac{300,000,000}{f_{(Hz)}}$$

in which λ is the wavelength in meters. Since the charge traverses the wire twice, the length of wire needed to permit the charge to travel a distance λ in one cycle is λ/2, or one-half wavelength.

Since the speed of light is a universal constant, either the frequency can be adjusted to a given wire length, or the wire length can be adjusted to a given frequency. Finally, by changing from the metric system to the English system and dividing the formula by two, the familiar and useful formula for a half-wavelength in space is:

$$L = \frac{492}{f_{(MHz)}}$$

where L is length in feet of a half-wavelength for a frequency, f, in MHz.

The final step is to take into account the ratio of length to diameter of the conductor. The smaller the ratio, the shorter the antenna will be for a given electrical length. This is illustrated for tubing elements in the graph **fig. 1.**

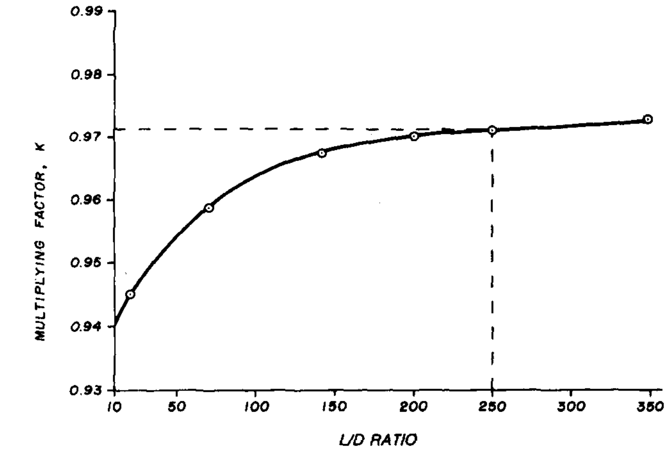

fig. 1. Ratio of half-wavelength to conductor diameter (K-factor for tubing elements).

A length-to-diameter ratio of about 4,000 to 1 is appropriate for a wire antenna in the HF range. A length-to-diameter ratio of, say 250 to 1 could apply to a resonant element made of aluminum tubing. The tubing element would be about 97 percent as long as a wire element for the same frequency. It is possible, then for a "thick" element to be quite a bit shorter than a

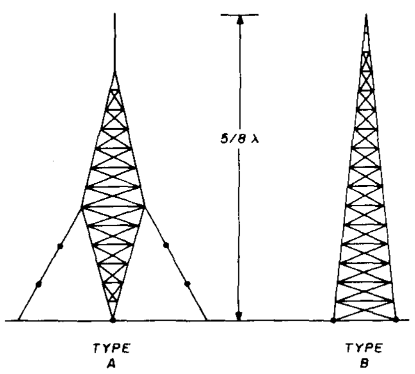

fig. 2. Early broadcast antenna towers.

"thin" wire element, or than the free-space dimension of a radio wave of a given frequency. No argument so far, is there?

what the broadcasters found out in 1934

In 1924 Stuart Ballantine showed that, for a given amount of radiated power, the field strength at the horizon would be greatest when the vertical antenna (over a good ground) was 0.64 wavelength high.[3] This was the concept behind the popular 5/8-wavelength vertical antenna.

This was of immense benefit to broadcast stations because it allowed them to have a signal about 40 percent greater than that provided by a 1/4-wave vertical antenna fed the same power. During the period between 1925 and 1930, many broad-cast stations in America and Europe switched over to the new antenna design.

In attempts to obtain this optimum situation the broadcaster had to erect a tower more than twice as high as had been used previously. Two types of tower designs were available, as shown in **fig. 2**. The type A installation consisted essentially of two towers placed base-to-base and held in a vertical position by four or more guy wires. The type B design was more conventional, with the four tower legs mounted on base insulators. No guy wires were required.

After using these towers for some months it became apparent that the results achieved were not consistent with theory. The promised gain failed to materialize, and the unwanted, high angle radiation was not appreciably reduced. In May, 1934, extensive tests were run on the radiation pattern of WABC (in Wayne, New Jersey), using an airplane to provide vertical pattern plots. The results were discouraging (**fig. 3**).

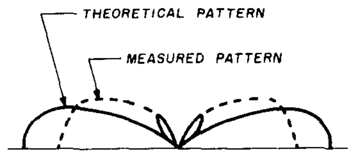

fig. 3. Airplane field strength measurements on WABC antenna showed radiation pattern was not what was expected.

The next step was to measure the current distribution along the tower. In the case of the type A design, the 5/8 wavelength tower should have the current distribution shown by curve *A* of **fig. 4.** But the measured current actually resembled curve *B*! The current distribution did not resemble the sinusoidal curve predicted by theory, nor was there a current reversal approximately a 1/2-wavelength from the top end of the antenna! The top portion of the antenna carried very little current and the bottom portion of the antenna nearest the ground carried most of the current.

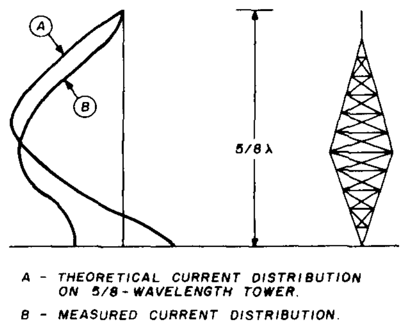

fig. 4. (*A*) Theoretical current distribution on 5/8-wavelength tower and (*B*) measured current distribution.

H.E. Gihring and G.H. Brown of the RCA Victor Company ran tests on antenna models built to scale for a wavelength of 4 meters. The tests on the models duplicated the results found by measurement on the larger broadcast antennas.[4] The clue was that the current distribution on the tower was *non-sinusoidal*, and the rules that applied to normal antennas with sinusoidal current distribution did not apply to towers of irregular cross section!

Armed with this information, tests were run on the type A tapered antenna tower at WCAU (in Philadelphia, Pennsylvania). This tower has an additional 100-foot shaft protruding out of the top. They found little current in the shaft and, again, no reversal of current at the half-wave point along the tower.

The final check was to build a 4-meter model antenna out of wire having a constant cross-section. They reported "substantial agreement" between theoretical and observed values.

problem defined how to solve it

Gihring and Brown had proved that it would be desirable to make the cross-section of the 5/8-wave antenna constant if it were to obey the theoretical laws and deliver the anticipated power gain. They proved this in simple fashion. They made a wooden framework the same size as the maximum tower cross-section for the WCAU tower and dropped wires down to the corners of a square frame placed at the base of the tower (**fig. 5**). Voila! Even with as few as four wires, the current distribution on the tower approximated the desired sinusoidal waveform and the radiation pattern proved to be what was predicted for the 5/8-wave antenna height.

So there it was. By summer, 1935, broadcasters had started to shift away from self-supporting towers in favor of uniform cross-section, guyed towers. And these are the tower designs that are in use today by the majority of broadcast stations around the world.

the taper effect

Although they had a different goal

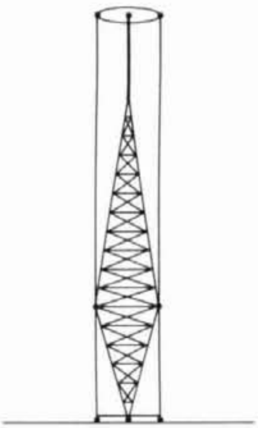

fig. 5. Wire frame suspended from "hat" atop WCAU tower restored proper current distribution along the tower.

in mind, Gihring and Brown had defined and described the so-called "taper effect" — that is, that normal assumptions about antenna length do not apply when the antenna element is not unifrom in cross-section throughout its length. The antenna can be "thick" or "thin" and all is well, but when it's tapered, all sorts of strange things seem to happen!

the discoveries of W3MWC and W6KPC

While the tapered tower effect was well-known in the broadcast industry, it remained unknown to the Amateur fraternity in general. The taper problem did not apply to VHF beam antennas, it seems, because most of them were made of a single section of tubing for each element and no taper was present. Even conventional 6, 10, and 20 meter beams had little, if any, taper. For experimenters who built HF beams with tapered elements, the puzzling results and poor beam performance could not be linked to the conventional element dimensions in use.

As far as I know, the first discussion of element taper in Amateur literature was presented by my good friend Frank Clement, W6KPC.[5] Frank found that his 14 MHz driven element ended up 17 feet 2 inches (5.23 meters) long because of the extreme taper. (Note that the element is longer than the conventional electrical half-wavelength.)

There the matter rested until 1967, when Jim Berger, W3MWC, attempted to build a 3-element, 40-meter beam with tapered elements. In a letter to *QST*,[6] Jim noted that he had to lengthen his elements to make the antenna work properly. The tapered driven element ended up 71 feet (23.6 meters) long (again, much longer than the conventional electrical half-wavelength.)

W2PV defines and solves the problem

Aided by data from W6KPC, I derived a simple chart that provided a correction factor for a tapered element, based upon the maximum and minimum diameters of the element. It proved to be practical, and a few beams with tapered elements were designed from my data with good results. However, I had no mathematical proof that my supposition was correct.

I pushed the matter to the back of my mind until the late Jim Lawson, W2PV, published a mathematical explanation of element taper in his monumental series of articles in *ham radio*.[7] The computer program he suggested was quickly compared against my heuristic (cut-and-try) data and I was pleased to find excellent agreement. A variation of the original program has since been published in *ham radio*.[8,9]

and the answer is

Yes, it is entirely possible for a "half-wave" element to be longer than predicted by conventional formulas *if* the element in question has a nonsinusoidal current distribution along it. One of the most common examples (there are others) is the simple tapered element having a non-uniform diameter along its length. But the means are now at hand to predict this aberration and to compensate for it.

the 80-meter Yagi at OH1RY

Build an 80-meter Yagi antenna?

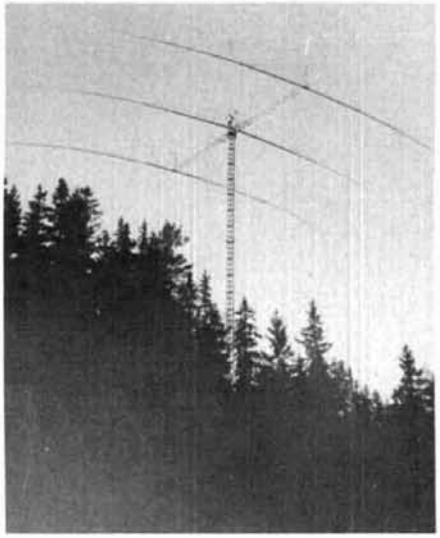

fig. 6. The 80-meter Yagi of Peter, OH1RY. If you look closely, you can see Peter standing atop the center of the beam.

Impossible. But Peter Kolehmainen, OH1RY did it! The antenna is shown in **figs. 6** and **7**. This monster is atop a 92-foot (30.6 meter) high tower placed on the crest of a 60-foot (18 meter) hill, making the beam about 150 feet (46 meters) above the surrounding territiory. The boom length (including the tip guying supports) is 72 feet (22 meters) long. The antenna itself weighs about a half-ton (454 kg).

Element taper? The element is 6 inches (15.24 cm) in diameter at the boom, tapering to 1/2-inch (1.27 cm) diameter at the tips! As you can imagine, this provides some bizarre element lengths. The driven element is 135.5 feet (41 meters) long for resonance at 3.8 MHz. The first photo shows Peter squatting on the driven element, which is hinge-mounted to heavy insulating plates bolted to the side of the boom. The weight of the element is supported by the small "mast" and guy wire assembly behind him (I wonder where the photographer was standing when this picture was taken?)

If you look at the photo of the beam, you'll see Peter standing atop the antenna, dwarfed in size by the monster he has created!

Does the antenna work? Just listen for OH1RY and judge for yourself!

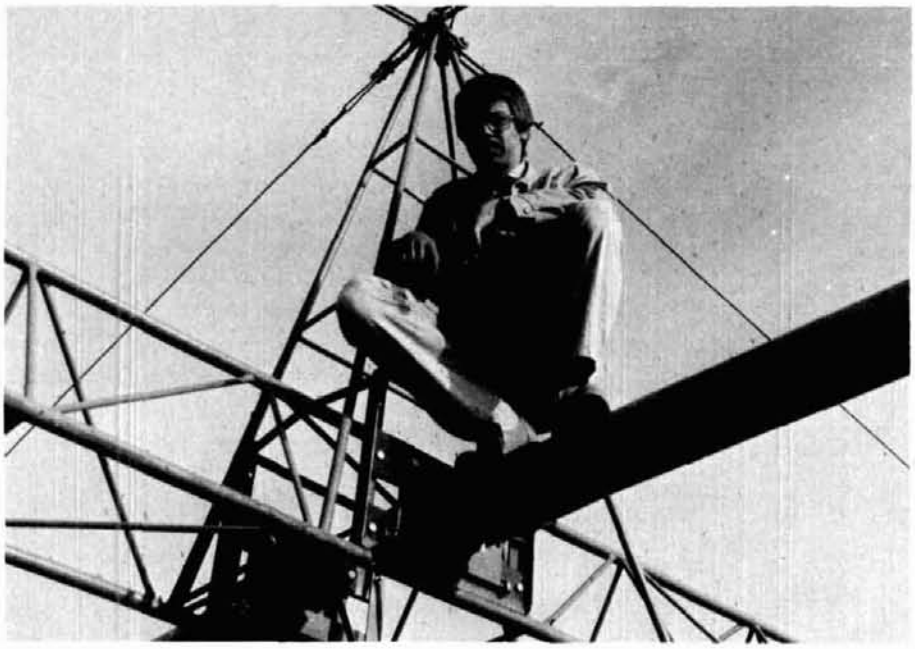

fig. 7. Peter, OH1RY, atop the driven element of his 80-meter Yagi. Center of element is 6 inches (15.24 cm) in diameter!

good reading from Canada

Our neighbor to the north, Yuri Blanarovich, VE3BMV, is the editor of a publication that all Amateurs (especially DXers) should be aware of. A first-class production *Radiosporting* covers all aspects of contest and DX operating — antennas, equipment, station operation, stories of DXpeditions — the works! I enjoy every issue of this publication. If you're interested in it, contact Yuri at Box 65, Don Mills, Ontario, Canada M3C 2R6. (I wish somebody would explain the British and Canadian postal code system!)

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Special offer: All nine issues are availabe from Ham Radio's Bookstore for $9.95 postpaid (U.S. only). All foreign orders FOB Greenville, NH 03048.
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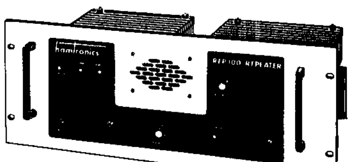

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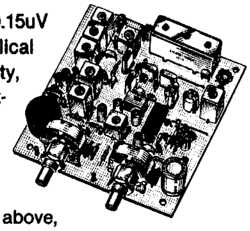

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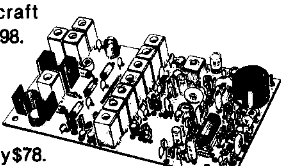

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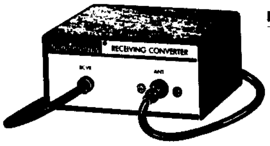

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146-148	28-30
144-148	50-54
220-222	28-30
220-224	144-148
222-226	144-148
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144-146	50-52
50-54	144-148
144-146	28-30

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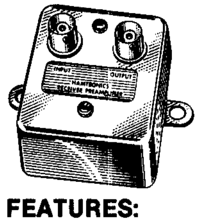

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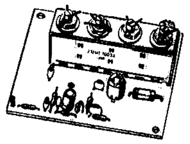

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tracking the hideous intermittent: part 1 — mechanical intermittents

Repair problems are never fun, especially since they take us off the air more times than not.

Probably the nastiest, meanest, and most contemptible of all repair problems are the intermittents. These come and go, usually occurring when it's least convenient. They almost never occur when you're ready to troubleshoot; you stand there, instrument probes in hand and brain engaged, only to find the darn set working properly. You turn your back, set the probes down, and — *zot!* — the trouble reappears momentarily and then disappears again.

Although I'm the first to admit that finding intermittents sometimes falls into the unholy realms of sorcery and witchcraft, certain things can be done to enhance the probability of success.

There's no such thing as a universal procedure for locating intermittents because different kinds of equipment have somewhat different requirements. To keep things simple, we'll limit the scope of this discussion to troubleshooting a high-frequency SSB transceiver with receive problems.

where to look

One thing you can do is educate yourself about the kinds of parts and faults most likely to create intermittent symptoms. Very high on the list are switches and relays. Because these devices are mechanical, they're subject to wear and tear. You'll find dirty internal electrical contacts, poor spring tension, and other faults causing intermittent symptoms. In many cases, a session with a pencil eraser on the contacts or a squirt of contact cleaner (for example, *Blue Stuff*) will work wonders. In other cases, however, only replacement will solve the problem.

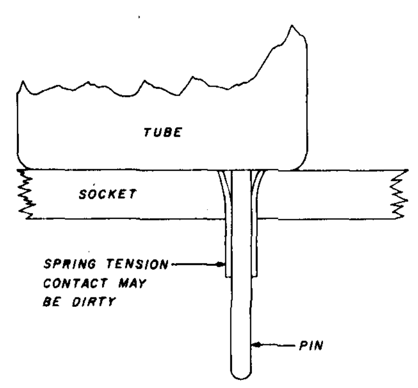

fig. 1. Dirty tube sockets create intermittent conditions.

Another potential sore spot is potentiometers. These components are variable resistors in which a shaft-operated wiper electrode rubs against a wirewound or carbon resistance element. If either the element or electrical contact on the wiper gets dirty, then operation can become intermittent. Unless the dirt has physically damaged the resistance element (as sometimes happens, especially on carbon elements), a simple squirt of contact cleaner will solve the problem. Be especially aware of potentiometers that normally pass direct current (DC) through the wiper connection. I recall a 1963/64 car radio model in which cost-conscious engineers eliminated a coupling capacitor from the volume control and audio preamplifier circuit, thereby making the volume control resistance part of the preamp transistor's bias network. Passing the DC bias through the control generated a massive warranty problem for the manufacturer as those volume controls were chewed up by the truckload!

The printed circuit board (PCB) is another common source of intermittent problems. Two forms of the problem are common: poor solder joints and damage, sometimes hidden, to the board. Both types of fault are especially aggravated in hot parts of the equipment: near power transistors, rectifiers, vacuum tubes, power resistors (2 watts and above), lamps and so forth. These areas sometimes can be identified by discoloration of the PCB. (We'll discuss PCB problems in a moment.)

In vacuum tube equipment, the tube socket can produce intermittent problems. If the tube pins or the socket contact (**fig. 1**) lose tension, then an intermittent connection results. These faults can be repaired in most cases. If dirt is the problem, remove the tube and gently clean its pins with a dime store ink eraser, spray the pins with a clear contact cleaner, and reinsert the tube into the socket. Next, pull the tube out of the socket and then reinsert it four or five times in a row. This action will clean the socket. Wait a hal

✓ 137

hour or so for the cleaner to dry, then turn the rig on to evaluate the results. If the intermittent remains, re-tension the socket contacts with either a tiny screwdriver tip or other sharp-pointed tool.

Components can be the source of some maddening intermittents. Unfortunately, some component problems tend to heal themselves the instant a probe is attached (especially semiconductors). Be especially wary of plastic packaged transistors, tubular (non-mylar) capacitors, and resistors. These components account for a large portion of the problems.

Shielded IF and RF transformers (**fig. 2A**) are frequent sources of intermittent faults. The coil wire attaches to the lugs on the base, and these sometimes break (see **fig. 2B**). In some cases, a careful worker can repair these transformers; it's merely a matter of resoldering — you'd be surprised how many escape the factory unsoldered!

finding the intermittent

The first step, crucial to quick success, is observation. Define in your mind what the rig is doing wrong, what functions are affected, and whether it happens on both receive and transmit. Narrowing down the possibilities allows you to restrict your efforts to a certain few stages, once you determine which stages may or may not be affected. For example, if the problem happens on SSB but not CW, or on receive but not on transmit, we can then infer that the problem is probably not in a stage that is common to both affected modes. Deciding which stages are likely candidates depends on understanding your transceiver; do a block diagram analysis and read any circuit descriptions provided by the manufacturer.

Some intermittents occur under vibration, touching, or thumping. A certain number of such problems are due to bad switches and potentiometers. A little *light* tapping with an insulated probe, a little jiggling, or visual inspection will often locate the source of the problem.

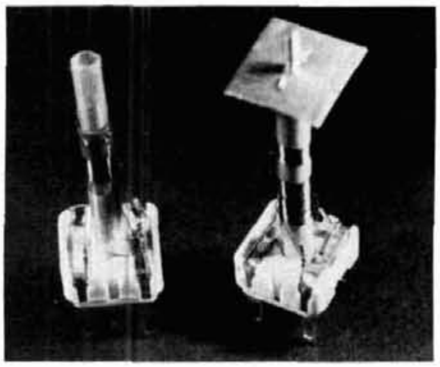

fig. 2A. RF/IF transformers.

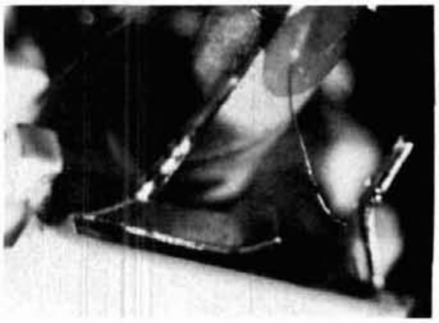

fig. 2B. Another cause of intermittency is traceable to broken coil lead/base LUG connections.

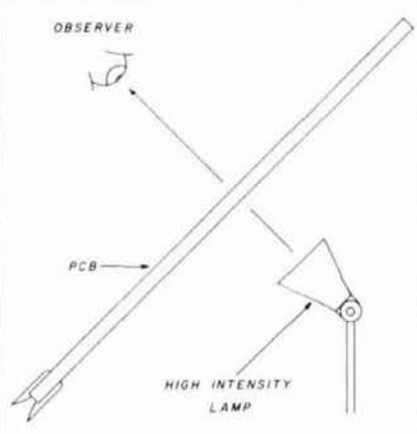

fig. 3. View the PCB with light shining through to find cracks.

Most mechanical faults are due to either bad PCB joints or bad components mounted on the PCB. Unfortunately, many of these problms fail to yield to the tapping method because any vibration at all, anywhere on the board, will produce the fault. Two approaches helpful in this regard don't require formal troubleshooting: visual inspection and shotgun solder touch-up.

Visual inspection involves examining every joint on the PCB with a 10X or so magnifying glass under adequate light. Examine the board two ways: first with the light shining on the soldered side, then with the light shining *through* the PCB from the component side (**fig. 3**). In the latter case, subsurface cracks in the PCB material can break a joint or track. Even if the joint or track appears normal it should be reworked.

Visual examination takes a certain amount of practice; one needs to develop a "small eye," that is, the ability to see defects where others would see a "normal" joint.

I usually inspect PCBs with a bottle of fingernail polish or a grease pencil handy. Especially on large boards, each apparent anomaly is marked so that I can find it easily later on. This habit is especially useful when using a magnifier because the glass will distort your perception of space.

Shotgun soldering is especially useful when the area of the intermittent is known, when the PCB is small, or when nothing else seems to work. I can recall another mobile radio receiver problem in which the VHF front-ends PCB had a high "bad joint" intermittent rate, but were difficult to remove and replace. In that case, the more elegant "visual inspection" method was not cost effective, so we pulled the PCBs, soldered every joint, and tinned every track. Rarely did this method fail on that particular problem.

At this point let me digress a little bit to answer the purists who would criticize this approach. I admit that the elegant method is to find the single bad joint or broken track and repair only that. Unfortunately, this approach can be time-consuming and may even be impossible. While the purist "supertech" is messing around trying to analyze which joint is bad, I'm going to fix the rig! Commercially, the shotgun approach is more profitable — and to Amateurs it means getting back on the air sooner.

Next month: Tracking down thermal intermittents.

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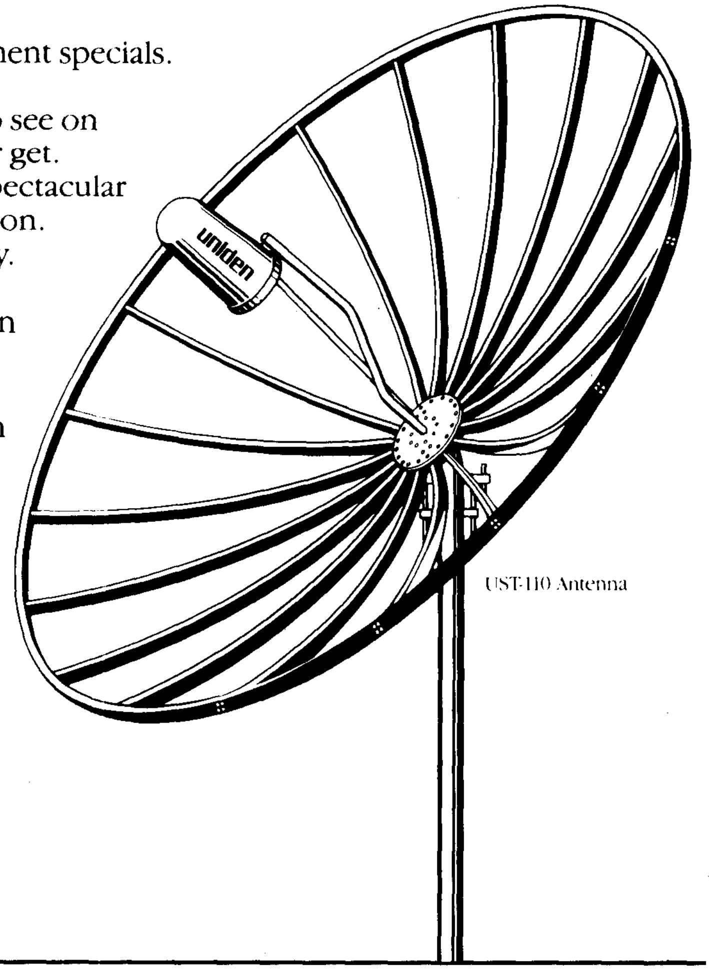

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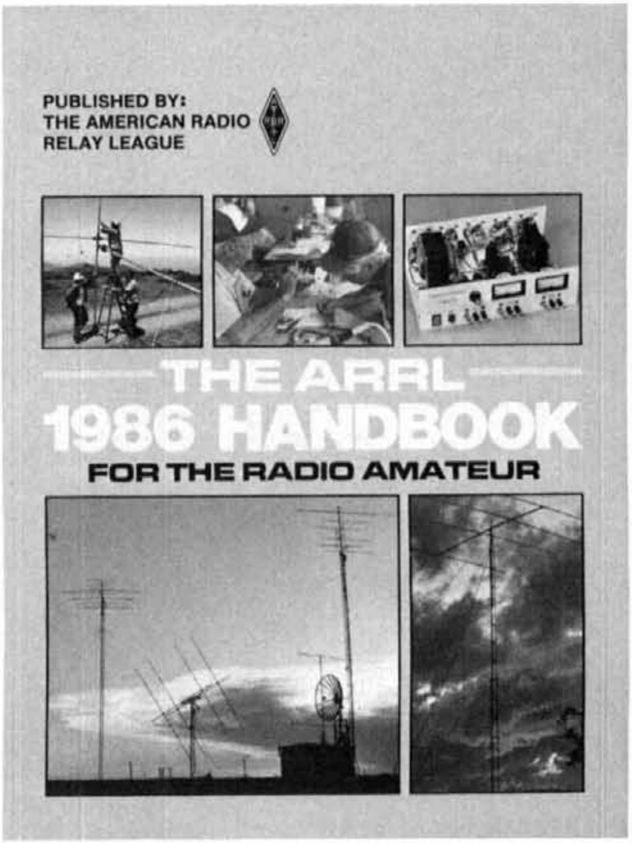

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digital frequency readout
using the Commodore 64

A ÷ by 16 prescaler designed for the Argosy I can be adapted to other transceivers

Although digital frequency readout is clearly a major advance in Amateur transceiver technology, many excellent rigs that offer most of the other advantages typical of state-of-the-art gear don't have digital readout. Yet it seems ridiculous to replace a good piece of equipment because of this one shortcoming. If you have such a rig, you might want to consider adding a digital frequency display as an accessory.

This can be done through the purchase or construction of a frequency counter, but such gadgets tie up both station space and dollars, and without special hookups can display only transmitted frequencies. Furthermore, when the station already contains a computer and monitor, it seems redundant to add yet another display with its associated batch of electronics.

I was doing a good job of break-in CW with a Ten-Tec Argosy and a Commodore 64 serving as a CW keyboard. With conditions becoming more and more difficult as the sunspot number fell, the need for sharp filters and "on-the-nose" schedules became too acute to be ignored, and the analog dial of the Argosy fell short of what was needed. Accordingly, I decided to make the computer display the required information.

Fortunately, the C64 contains an array of hardware timers that operate independently off the central processor and can be accessed through the user port. It also contains a stable frequency reference in the form of the machine clock. The timers perform the comparison of unknown and reference frequencies. The mathematics necessary to display the operating frequency, formulated in BASIC, run in real time in order to provide a continuous readout. The system is easy to implement and debug, performs beautifully, and is readily adaptable to other popular transceivers.

timer

The timers are part of two 6526 Complex Interface Adapter (CIA) integrated circuits contained in the machine. One of the two ICs is dedicated primarily to the keyboard interface, but its timers are partly accessible through the user port. The second CIA is dedicated to the user port and the serial interface, and its functions are fully accessible.

The timers are 16-stage binary counters that can be preset to any count between 1 and 65,535. They count down from the preset value and deliver an output when the count passes zero. Thus, they can divide an input frequency by any integral number within their range. Furthermore, they can be cascaded by appropriate instructions to form a longer counter chain.

The signal counted can be either an external input or the machine clock. The latter runs at 1.022727 MHz and is derived from a master crystal oscillator that also generates the color subcarrier in a TV.

The counting rate is limited to about 500 kHz by the internal mechanics of the interface chip. It is therefore necessary to bring the frequency to be measured down into the range below 500 kHz. However, an aliasing effect permits moderate extension of the limit with appropriate modification of the programmed mathematics.

By Clifford J. Bader, W3NNL, 1209 Gateway Lane, West Chester, Pennsylvania 19380

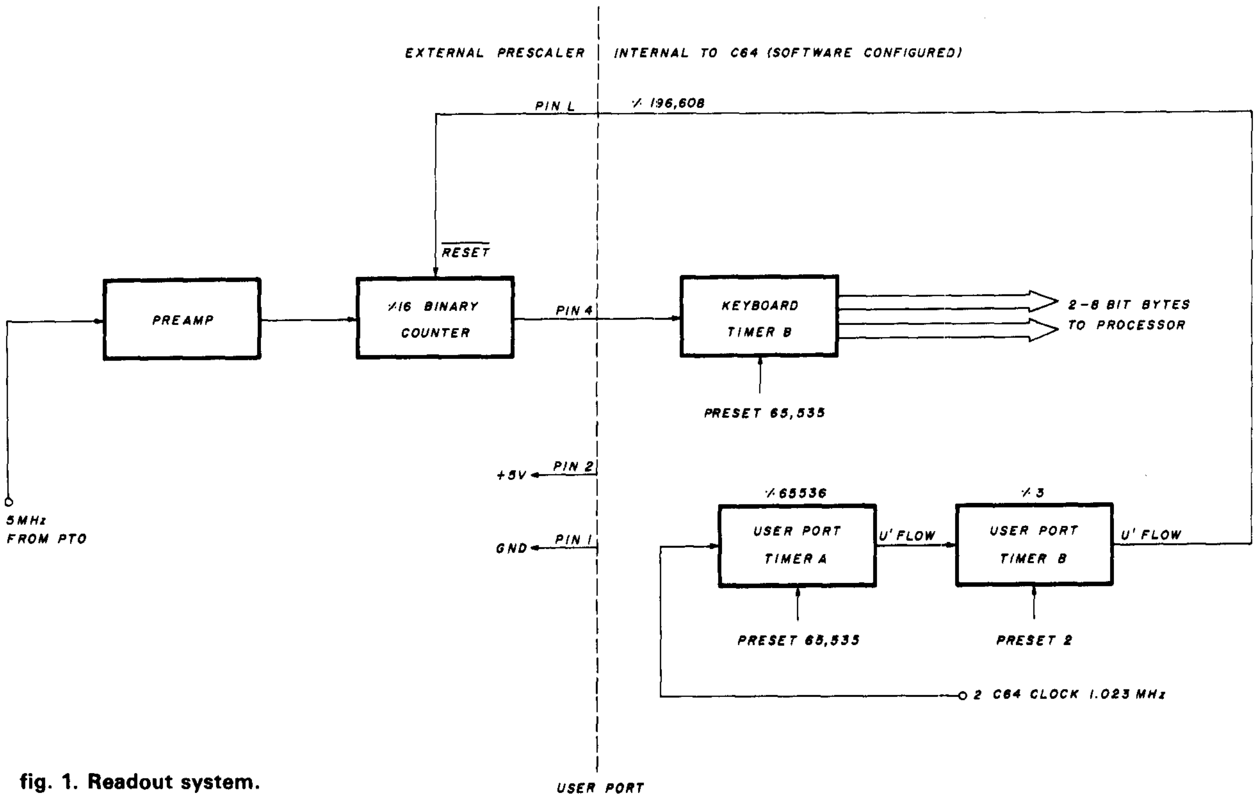

fig. 1. Readout system.

design considerations

A key requirement for digital frequency readout is precise gating of the counter that records the frequency to be measured. This would be difficult to do if the gating were done through software, since the machine cycle times for executing BASIC instructions are a significant fraction of the counting period required. Fortunately, the designers of the CIA arranged for direct access of the timer output through the user port, without intervention by the computer's processor; thus, one timer can be used to precisely gate another by the addition of simple external circuitry, and the result can be examined by the computer at its leisure.

In general, neither the transmitted nor the received frequencies are present as a steady-state signal (except in the case of a direct-conversion system), so an indirect method of determining the frequency must be used. Since most modern gear uses a master oscillator covering a fixed range, in conjunction with crystal-controlled heterodyning oscillators for the various bands, it is generally satisfactory to measure the master oscillator frequency and to apply appropriate corrections to the display. The stability of the heterodyning system is usually good enough to make the correction a constant factor, and no significant error results from warm-up or temperature changes.

My Argosy oscillator operates in the 5-MHz region, as do the oscillators in many other transceivers. To get the frequency below the 500-kHz limit, the frequency to be measured must be reduced by a factor of better than 10. Translation through a mixer could be used, giving an output of 0 to 500 kHz as the oscillator covers 5 to 5.5 MHz, but an additional crystal oscillator would be needed and the mixer output circuit would have to be broadbanded over the range from DC to 500 kHz.

It's easier to use a frequency divider in the form of a simple integrated-circuit counter. For example, a four-stage binary counter divides by 16, giving an output frequency range of 312.5 kHz to 343.75 kHz as the input varies from 5 MHz to 5.5 MHz.

An obvious disadvantage of the divider is the loss of precision associated with the compressed frequency range. The precision can be regained, however, by lengthening the counting interval by an equivalent factor. Normally, achieving 100-Hz resolution — which is typical of most digital readout transceivers — would require counting for 0.01 second; with the divide-by-16 prescaler, the time must be lengthened to 0.16 second or more. Fortunately, a repetition rate of two or three times per second is fast enough for a useful real-time readout, so the divider scheme is practical. It is easy to implement, requiring only the binary counter and a transistor buffer-driver to amplify the small amount of RF taken from the 5-MHz transceiver oscillator. Power can be taken from the computer's user port.

The computer program for performing the readout and display handles a number of functions. First, it arranges the timers for the task at hand. Then it starts the count cycle running and monitors for completion of the cycle. Next it obtains the resultant count and performs the mathematics necessary to deduce the oscillator frequency from the count. It applies the appropriate corrections for the band and mode in use, as input by the operator. Finally, it displays the resultant figure on the screen, and initiates a new cycle. Despite all this activity, the program is a short one, requiring fewer than 50 lines of typing and only a few seconds to load from tape or disk.

system implementation

The readout system is shown in **fig. 1**. Timer *A* of the user port divides the machine clock frequency by 65,536. When its count passes zero a pulse is delivered to user port timer *B*. The latter is preset to a count of 2; when it also indicates an underflow (at a clock count of 65,536 × 3 = 196,608), line PB7 (Pin L) of the user port switches from plus 5 volts to zero volts. This voltage transition gates off the external counter.

The counting interval is 196,608/1,022,727 = 0.192239 second.

Counter *B* of the keyboard interface CIA counts the input pulses delivered from the external divide-by-16 prescaler through Pin 4 of the user port. It is preset to 65,535 at the start of each cycle and counts down until the external signal is gated off.

The schematic of the external prescaler is shown in **fig. 2**. The binary counter is a TTL 74197, which is capable of 70-MHz operation. There are numerous other possible choices, including some CMOS varieties; however, with the latter it may be necessary to run the prescaler at a higher voltage than 5 volts to achieve the 5 MHz counting speed. This would in turn lead to power supply and interfacing complications.

A cursory glance at the transistor buffer circuit suggests that it violates all the rules of stable biasing for amplifiers. So it does, but the objective is not linear reproduction of the signal, but rather the development of a square wave drive from a hundred millivolts or so of sinusoidal signal. Thus, it is permissible to operate the stages at a small degree of either saturation or cutoff. The resistor values shown keep the 2N2222s in such a state.

The coupling to the transceiver is through a simple capacitive pickoff and a 3-foot (0.9 meter) shielded cable to the prescaler. The loss in signal caused by the voltage-divider effect of the cable capacitance is made up by the two-stage amplifier in the prescaler.

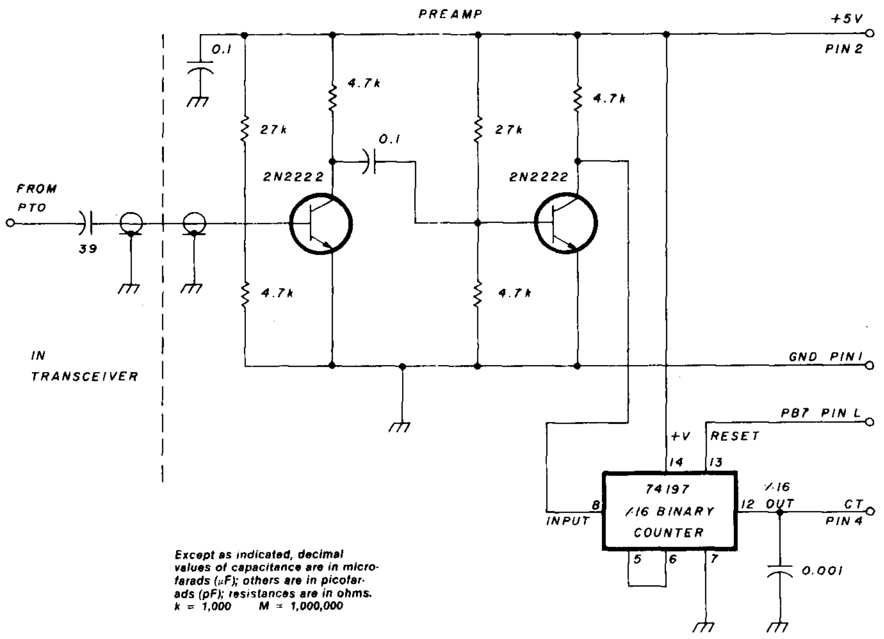

fig. 2. Prescaler schematic. Bias resistor values are chosen for a small amount of saturation or cutoff. Stage delivers square wave drive from about a hundered millivolts of sinusoidal signal.

The advantage of this approach is that it requires no active hardware inside the transceiver and produces no large-amplitude square waves near the transceiver's receiver circuitry.

In my Argosy, the 39 pF capacitor is connected to the output (rearmost) terminal of the PTO assembly and a shielded cable is run from there to one of the spare RCA jacks on the rear panel. Many transceivers have the VFO signal already available on the back panel and require no internal modification. In general, the pickoff point should be at the output of the VFO buffer, and the rig should be checked after connection of the prescaler to make sure that there is no loss of output.

The prescaler is located close to the user port and enclosed in a small aluminum box (**fig. 3**) to prevent radiation of harmonics of the scaled-down frequency every few hundred kilohertz throughout the spectrum. Such radiation is also suppressed by the 0.001-μF capacitor from the prescaler output to ground, which slows down the edges of the square wave going into the port.

At W3NNL, the prescaler shares the user port with an MFJ-1228 CW/RTTY interface, and is piggybacked on the latter (**fig. 4**). There is only one port line (Pin L) in conflict, and a switch is provided to transfer it from frequency readout to the MFJ. I have also combined a CW keyboard program (not shown) with the frequency readout.

In the absence of such a piggyback scheme, it will be necessary to procure a connector with the required 0.156-inch (4-mm) contact spacing. These seem to turn up at hamfests only in much longer sizes than the 24-pin variety needed for the user port; however, the excess length is easily removed with a hacksaw.

computer program

The BASIC program shown in **fig. 5** can be followed using the memory map presented in the C64 Programmer's Reference Guide. **Lines 110** through **290** are concerned with acquiring the operator-specified band and mode, and defining the pre-established correction factors. The section from **line 300** through **420** sets up the timers, runs the count cycle, and calculates the frequency. The remainder of the program is devoted to formatting and displaying the output and starting a new cycle.

The timer interface uses POKE and PEEK statements directed to the appropriate addresses. The count in timer *B* of the keyboard CIA is picked off in two eight-bit bytes, and the number of pulses is calculated and multiplied by a factor which yields the original input frequency to the prescaler. The low-edge oscillator frequency is subtracted from the input frequency, and the lower edge of the band in use is added. Finally, corrections unique to the individual transceiver are

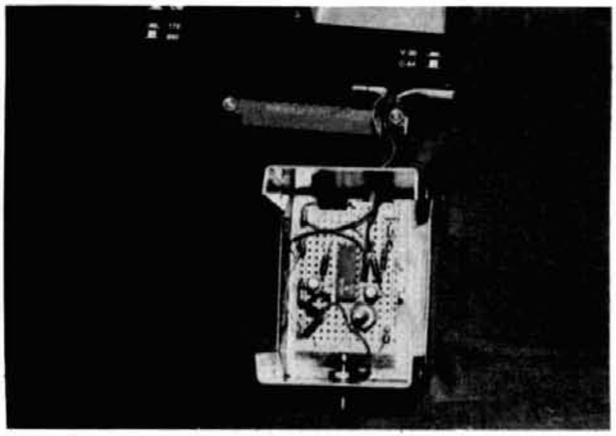

fig. 3. Prescaler is enclosed in a small aluminum box to prevent harmonic radiation.

either added or subtracted; these corrections take care of crystal-tolerance errors in the heterodyne frequencies, deliberately introduced offsets such as those used in the Argosy to avoid birdies, and shifts in the received and transmitted frequencies dependent on the mode of operation selected (CW or either sideband).

The correction consists of a term *K* representing the conversion-oscillator related effects, a factor *D* representing the offset between CW and normal sideband operation, and a multiple of *D* which is the shift incurred when the reverse sideband is selected. Of course, if only one mode is to be used, *D* may be omitted from the selection statements and from the frequency equation of **line 400**, and the mode select routines of **lines 130-160** and **270-280** can be omitted. The value of *K* can be determined for the mode of interest.

Several tasks are associated with formatting and display. The screen is cleared and the "FREQ = " leader is printed, followed by the frequency, a wide space, and the mode entered. To avoid a string of meaningless extra digits after the decimal point, the computed frequency is rounded off to the nearest 0.1 kHz. To eliminate the visually unpleasant sensation produced by the C64's dutiful suppression of the decimal point and following zero on integral kilohertz readings, some jockeying is performed to tack the point and zero back on. Finally, compensation is made for the leading-zero suppression, which occurs when tuning from above 10 MHz, to below 10 MHz, and which would otherwise shift the display left and expose a spurious right-hand digit.

The above action is repeated every few hundred milliseconds, except that the screen is left uncleared after the first cycle. Clearing produces flicker and is unnecessary unless the format changes.

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fig. 4. Prescaler mounted on MFJ interface.

the display portion of the program be typed *exactly* as specified, including all embedded punctuation marks.

correction factor determinations

When the program is first typed, **lines 180** through **280** should be omitted. The missing lines may be entered after determining the *K* and *D* factors as described below.

If the correct nominal low-edge oscillator frequency has been entered on **line 290**, the indicated frequency will be somewhere within 10 kilohertz or so of the true value when the program is run and WWV, CHU, or the crystal calibrator is tuned in. Before starting the correction factor procedure, the calibrator should be checked to make sure it is accurately tuned to the standard-frequency station.

To determine *K* for a given band, only one measurement is necessary. With the rig set in the normal sideband position for the band in use, the crystal calibrator should be tuned to zero beat. The frequency indicated by the display should be noted and subtracted from the actual frequency of the calibrator harmonic. The result is the value of *K*. This operation should be repeated for each band or bandswitch segment and the numbers recorded for entry into the program (don't forget the minus signs where applicable).

Next, the transceiver should be set for CW and the calibrator harmonic tuned for the proper CW pitch rather than for zero beat. The direction and magnitude of the change in indicated frequency should be noted. The change will normally be about 0.8 kHz. An accurate value can readily be determined if the rig has a sharp audio or crystal filter. If a separate receiver is available, a still more accurate measurement can be made by noting the display reading when the transceiver is placed in the transmit mode and zeroed in the external receiver with a known reference. The RIT or OFFSET control should be set to zero for this measurement.

The value of *D* obtained is positive if the indicated frequency decreases as compared to the zero beat setting, and negative if it increases. By way of example, in the program (**fig. 5**) at 10 MHz the indicated frequency with WWV at zero beat in the SSBN (normal sideband) mode was 10010.8 kHz, leading to a *K* of minus 10.8. With the WWV carrier peaked in the audio filter, the indicated frequency increased another 800 Hz to 10011.6 kHz, yielding −0.8 for *D*. The numerical value of *D* holds for all bands, but the sign changes as the rig implements CW on different sides of zero beat.

Finally, the opposite sideband should be selected and the zero-beat procedure followed. The correction determined should be divided by D to give the multiplier used in **line 280**. Again with reference to **fig. 5**, my display read 10014.2 in the reverse (USB) mode, or 3.4 kHz higher than SSBN. This is 4.25 times as large as the CW correction and in the same direction, so the multiplier in **line 280** becomes 4.25.

operation

The program asks for entries of the band in MHz and the mode (0 for CW, 1 for normal SSB, and 2 for reverse SSB). It then displays the frequency to the nearest 0.1 kHz and the mode in use. A flickering of the display between two adjacent tenths digits indicates that the frequency is approximately halfway between the two values.

The readout follows the incremental tuning on receive and shows the transmitted frequency when the key is pressed or the mike activated. If there is considerable RF in the station the readout may be erratic on transmit, but will work if the drive is decreased to reduce the spurious RF.

To change the band and/or mode in use, press the f1 key. This restores the prompts and starts the process again.

adaptation to other transceivers

As described, the program and hardware should work with the Ten-Tec Omni as well as the Argosy. However, a number of other transceivers use upper/lower sideband selection rather than normal/reverse for the band in use. In general, its merely necessary to change the format, substituting LSB and USB for SSBN and SSBR. Proper choice of correction factor values and algebraic signs will then produce equivalent performance.

Of more concern is the VFO frequency and its relationship to output frequency. Both the Kenwood TS520S and the Yaesu FT101E use backward-tuning VFOs' that is, the low-band edge corresponds to maximum VFO frequency. This requires modification of the frequency equation of **line 420** to read:

```
110 REM DIGITAL FREQUENCY READOUT BY W3NNL 3/85
120 PRINT CHR$(147)
130 INPUT "BAND MHZ";B:INPUT"MODE (0=CW, 1=SSBN, 2=SSBR)";M
140 IF M=0 THEN M$="CW"
150 IF M=1 THEN M$="SSBN"
160 IF M=2 THEN M$="SSBR"
170 REM K AND D FACTORS BELOW APPLY TO W3NNL ARGOSY ONLY
180 IF B=3.5 THEN K=-.1:D=-.8
190 IF B=7 THEN K=-.4:D=-.8
200 IF B=10 THEN K=-10.8:D=-.8
210 IF B=14 THEN K=-.4:D=.8
220 IF B=21 THEN K=-10.4:D=.8
230 IF B=28 THEN K=-11.3:D=.8
240 IF B=28.5 THEN K=-11.8:D=.8
250 IF B=29 THEN K=-11.6:D=.8
260 IF B=29.5 THEN K=-11.5:D=.8
270 IF M=1 THEN D=0
280 IF M=2 THEN D=4.25*D
290 E=5000:REM ARGOSY PTO FREQ KHZ AT LOW BANDEDGE
300 PRINT CHR$(147)
310 POKE56589,0
320 POKE56590,1
330 POKE56582,2:POKE56583,0:POKE56591,16
340 POKE56591,71
350 POKE56327,255:POKE56326,255
360 IF PEEK(56577)>127THEN 360
370 H=PEEK(56327):L=PEEK(56326)
380 POKE56335,16
390 POKE56335,33
400 N=256*(255-H)+255-L
410 IF N<32768 THEN N=N+65536
420 F=.08322975*N-E+1000*B+K+D
430 PRINT CHR$(19):PRINT"FREQ =";
440 F=10*F
450 IF F-INT(F)<.5 THEN 470
460 F=F+1
470 F=INT(F)/10
480 IF F<10000 AND F>9000 THEN 560
490 IF F-INT(F)<>0THEN 520
500 PRINTF;:PRINT CHR$(157);
510 PRINT".0";:PRINT M$:GOTO 530
520 PRINTF;:PRINT M$
530 GET C$:IF C$=CHR$(133) THEN 120
540 IF PEEK(56577)<128 THEN540
550 GOTO360
560 PRINT CHR$(29);
570 GOTO 490

READY.
```

fig. 5. C-64 program for digital frequency readout.

420 F = E − .08322975*N + 1000*B + K + D

The TS520 VFO tunes from 5.5 to 4.9 MHz, so the value of E in **line 290** becomes 5500. The FT101 VFO tunes from 9.2 to 8.7 MHz, so E for this rig is 9200.

Since 9200/16 = 575, the FT101 pushes the computer past its upper frequency limit. This is where the previously mentioned aliasing effect comes to the rescue: the increasing rate at which pulses are missed causes the timer to slow down in exact proportion to the frequency excess. It turns out that correct results are obtained if the count is subtracted from 2 × 65536 = 131,072. Thus, **line 410** should be changed to read: 410 N = 131072-N

Rigs that have provision for 160 meters require the insertion of a correction-factor line for that band in the block between **lines 170** and **270**. For the TS520, *B* should equal 1.8, and for the FT101, *B* should equal 1.5. **Line 200** may of course be omitted for rigs which do not have a 10-MHz band.

Both the TS520 and FT101 have external access to the VFO. The TS520 VFO buffer is available through a 2:1 resistive divider at the VFO phone plug connector, and through direct connection at Pin 1 of the EXT VFO socket. The former connection is preferable if enough signal is obtained to drive the prescaler. The FT101 VFO is available at Pins 6 or 7 of the EXT VFO socket.

The program in **fig. 5** will accommodate oscillator frequencies from about 2.7 to 8 MHz. Frequencies below 2.7 MHz can be handled if **line 410** is omitted.

final comments

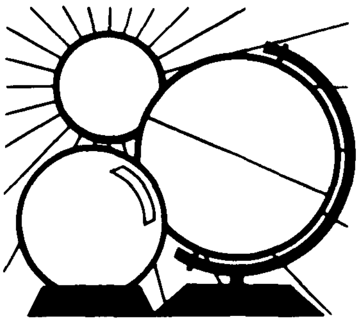
The most likely causes for failure of the system to operate are typing errors in the program or a problem in the prescaler. If the latter is running, it should be possible to hear harmonics at multiples of the divided-down frequency if the receiver antenna is brought near the circuit board. An analog DC voltmeter will read about 2.5 volts when connected to Pin 12 of the 74197. Some experimentation with preamplifier base resistor and input coupling capacitor values may be necessary if the VFO output is very low.

One very quickly becomes addicted to the circuit, to the extent that the rig is never on unless the computer is first fired up. It is satisfying to be able to set the display to 14000 kHz on a seemingly dead 20-meter band and have one of the beacon stations pop out right in the center of the audio passband.

acknowledgements

Thanks are due to Earle Lewis, W3JKX, Fritz Hauff, W3NZ, and Dick Briner, WB3GVU, for furnishing the Kenwood and Yaesu manuals. The photographs were taken by my son-in-law, Herb Hoppe, Jr.

ham radio



DX FORECASTER

Garth Stonehocker, KØRYW

winter DX season

November through February constitutes the winter DX season. Because the D and E regions of the ionosphere receive less energy from the sun in the northern hemisphere during this time, less ionization occurs. Therefore, the daytime attenuation of radio signals is lower in winter than during the rest of the year.

Attenuation is a result of signal energy being absorbed by ions in the D region (35-50 miles or 60-80 km) above the earth. The amount of absorption is related to the zenith angle* to the sun from the points where your path crosses this D region. And on any propagation path, absorption increases with the number of transits of the D region and varies inversely with frequency. So in working DX, it pays to use the higher frequency bands to obtain more distance per hop (resulting in fewer transits) and less signal loss.

This is why we generally think of 6, 10, or 15 meters for DXing. But in winter, particularly near sunspot minimum, we have the opportunity to work DX on the lower frequency bands with lower signal loss, day or night, than at any other time of the year. But you can't *always* count on it; signals traveling a high latitude path may be poor for several days at a time. This is known as the winter anomaly.[1]

Along with the lower signal attenuation, the QRN decreases as fewer local thunderstorms pass through your area and the large thunderstorm areas near the equator move further south, requiring more than one hop to get to us. This decreases the noise some 6-8 dB, which is particularly noticeable on the 160, 80, and 40-meter bands.

Even though ion production in the D, E, and lower F regions is lower, ions are better able to diffuse and drift upward along the geomagnetic field lines into the F region. This layer is the major factor in defining the maximum usable frequency. In winter this maximum usable frequency rises rapidly as the sun rises each day, peaking just after noontime, then diminishing during the afternoon, evening, and through the night to a low value just before dawn the next day. The exception to this situation is for locations nearer to the equator, where the ionization continues to drift and diffuse up during the afternoon and evening to become the transequatorial maximums described in my October, 1983 column.[2] The maximum usable frequency peak reached each day and the depth of the predawn minimum frequency of the next morning are related to the solar flux of the day. The higher the flux that day, the higher the frequency peak and the lower the dip the next morning.

Another advantage during the winter season is that the geomagnetic field is least disturbed during November and December. This manifests as least variation of the magnitude and direction of the geomagnetic field lines in an hour's time. This translates into fewer periods of QSB during these months.

last-minute forecast

The first and second weeks of November are expected to favor the higher HF bands, 10 through 30 meters. The solar flux is expected to be higher at this time of the month and result in higher MUFs. If the geomagnetic field is also disturbed at this time then transequatorial propagation on southern paths should also be expected. More hours of darkness, less QRN, and stable signal conditions give an edge to the lower bands for east-west and northern DX contacts this time of year. The lower HF bands are expected to be best the last two weeks of the month. You can update this forecast daily by listening to the time and frequency radio station, WWV, on 2.5, 5, 10, 15, and 20 MHz at 18 minutes after each hour. When the solar flux, as announced, is below 75 and the geomagnetic A is less than 15 or K is less than 4 the lower bands should be best. If the geophysical indices are higher, consider using the higher HF bands instead.

The Taurids meteor showers will occur from October 26 to November 22, with a maximum count of ten per hour from the 3rd through the 10th of November. Lunar perigee is on the 12th, and a full moon falls on the 27th. A total (totality of 1 minute 59 seconds duration) eclipse of the sun is calculated to be visible on November 12th way down in the Antarctic regions. It starts south of Africa at 1209 UT and moves to the tip of South America, ending at 1612 UT. The bands open to Antarctica on the accompanying propagation chart should lower to 40 meters and then recover during the above time period on eclipse day. Try for a contact!

band-by-band summary

Ten, twelve, and fifteen meters, the day-only DX bands, will be open from morning to early evening almost every day, and to most areas of the world. The openings on the higher of these

*The Zenith angle is the angle measured from directly above an observer to the sun (0 degrees when the sun is directly overhead, 90 degrees when the sun is at the horizon).

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102	114	126	138	150	162	174	186	198	210	222	234	246	258	270	282	294	306	318	330	342
103	115	127	139	151	163	175	187	199	211	223	235	247	259	271	283	295	307	319	331	343
104	116	128	140	152	164	176	188	200	212	224	236	248	260	272	284	296	308	320	332	344
105	117	129	141	153	165	177	189	201	213	225	237	249	261	273	285	297	309	321	333	345
106	118	130	142	154	166	178	190	202	214	226	238	250	262	274	286	298	310	322	334	346
107	119	131	143	155	167	179	191	203	215	227	239	251	263	275	287	299	311	323	335	347
108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
109	121	133	145	157	169	181	193	205	217	229	241	253	265	277	289	301	313	325	337	349
110	122	134	146	158	170	182	194	206	218	230	242	254	266	278	290	302	314	326	338	350
111	123	135	147	159	171	183	195	207	219	231	243	255	267	279	291	303	315	327	339	
112	124	136	148	160	172	184	196	208	220	232	244	256	268	280	292	304	316	328	340	

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ASIA FAR EAST	*80*	*80*	*80*	*80*	*80*	*40*	*40*	40	40	*40*	*40*	*40*	*40*	*40*	*40*	40	40	40	40	30	30	30	20	30	N
EUROPE	80	40	40	40	40	30	20	20	20	20	30	*40*	*40*	*40*	*40*	*40*	*40*	*40*	*40*	40	40	40	40	40	NE
S. AFRICA	20	20	20	15	12	10	10	10	10	12	15	*30*	*30*	*30*	*30*	*30*	*30*	20	20	20	20	20	20	20	E
S. AMERICA	10	10	10	10	10	10	10	10	10	12	15	*30*	*30*	*30*	*30*	*20*	20	20	20	20	20	20*	12	10	SE
ANTARCTICA	10	12*	12	12	12	12	12	12	15	20	*30*	*30*	*30*	*20*	*20*	*20*	*20*	20	20	15	15	12	12*	10	S
NEW ZEALAND	10	10	10	12	12	15	20	20	*20*	*30*	*30*	*30*	*30*	*30*	*20*	*20*	*20*	20	20	20	15	12	10	10	SW
OCEANIA AUSTRALIA	10	12	12	15	20	20	20	*20*	*20*	*30*	*30*	*30*	*30*	*30*	*20*	*20*	20	20	20	20	15	12	10	10	W
JAPAN	20	20	20	20	20	*40*	*40*	*40*	*40*	*40*	*40*	*40*	*40*	*40*	*40*	40	40	30	30	30	20	20	20	20	NW

MID USA

	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	MST
ASIA FAR EAST	*80*	*80*	*80*	*80*	*80*	*40*	40	40	40	40	30	*40*	*40*	*40*	*40*	*40*	40	40	40	40	40	30	30	30	N
EUROPE	80	80	40	40	40	30	20	20	20	20	20	30	*40*	*40*	*40*	*40*	*40*	*40*	*40*	*40*	40	40	40	40	NE
S. AFRICA	20	20	20	15	12	10	10	10	10	10	12	12	15	*30*	*30*	*30*	*30*	*30*	20	20	20	20	20	20	E
S. AMERICA	10	10	10	10	10	10	10	10	10	12	12	15	*30*	*30*	*30*	*30*	*20*	20	20	20	20	20	15	12	SE
ANTARCTICA	12	12	12	12	12	12	12	12	15	20	*30*	*30*	*30*	*20*	*20*	*20*	*20*	20	20	20	20	15	12	12	S
NEW ZEALAND	10	10	10	12	12	15	20	20	*20*	*20*	*30*	*30*	*30*	*30*	*30*	*30*	20	20	20	20	20	15	12	10	SW
OCEANIA AUSTRALIA	10	12	12	15	20	20	20	*20*	*20*	*30*	*30*	*30*	*30*	*30*	*30*	*20*	20	20	20	20	20	15	12	10	W
JAPAN	20	20	20	20	20	*80*	*80*	*40*	*40*	*40*	*40*	*40*	*40*	*40*	*40*	40	40	40	30	30	20	20	20	20	NW
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EASTERN USA

	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	EST
ASIA FAR EAST	*80*	*80*	*80*	*80*	*80*	40	40	40	40	40	40	30	30	*40*	*40*	*40*	40	40	40	40	40	40	40	40	N
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CARIBBEAN S. AMERICA	12	10	10	10	10	10	10	10	10	12	12	15	15	*30*	*30*	*20*	*20*	*20*	20	20	20	20	20	15	SE
ANTARCTICA	12	12	12	12	12	12	12	12	12	15	20	*20*	*30*	*30*	*30*	*20*	*20*	*20*	20	20	20	20	20*	15	S
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OCEANIA AUSTRALIA	12	12	12	15	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*30*	*30*	*30*	*30*	*30*	20	20	20	20	20	20	15	W
JAPAN	20	20	20	20	30	*80*	*80*	*80**	*80**	*40*	*40*	*40*	*40*	*40*	*40*	*40*	40	40	40	40	40	40	30	30	NW

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides the MUF during "normal" hours.

*Look at next **higher** band for possible openings.

bands will be shorter, occur closer to local noon, and provide paths mainly to the southern hemisphere with a possibility of transequatorial openings.

Twenty, thirty, and forty meters are both day and night bands. Twenty is the maximum usable band for DX in the northern directions these days during the daytime, then teams up with 30 meters to fill in through the night for the day-only bands. Forty meters becomes the main over-the-pole DX daytime band, with some hours covered by 30. This path may be affected by anomalous absorption during a few days of the month.

Eighty and one-sixty meters, the night-only DX bands, will exhibit short-skip propagation during daylight hours, then lengthen for DX at dusk. These bands follow the darkness path, opening to the east just before your sunset, swinging more to the north-south near midnight, and ending up in the Pacific areas during the hour or so before dawn. Eighty is the maximum usable band for some night hours now during sunspot minimum; consequently, signal strength and signal quality can be expected to improve. One-sixty may also be better. Remember the DX windows of 3790-3800, 1825-1830, and 1850-1855 kHz.

references

1. Garth Stonehocker, KØRYW, "DX Forecaster," *ham radio*, Decermber, 1984, page 63.
2. Garth Stonehocker, KØRYW, "DX Forecaster," *ham radio*, October, 1983, page 92.

ham radio

a scanner for CB to 10-meter conversions

Diode matrix replaces 40-position selector switch

There have been many articles on CB-to-10 meter conversion projects over the last few years, one of which was an excellent article by MacFarquhar and Grant[1] in which they described the steps necessary to convert a Citizens Band AM radio to an FM transceiver operating on 10 meters. In this article, we show how to replace their 40-position channel selector switch with some digital logic that adds the ability to scan up to 20 channels. In addition, we described a way to obtain a 100 kHz offset for repeater work without using a second crystal. All the other features of MacFarquhar and Grant's original modification are preserved.

If you already have a converted CB, enough information is provided here to build the scanner; if you're starting the project from scratch, the MacFarquhar and Grant article will be necessary.*

circuit description

Since the CB was designed for mobile operation, the converted radio must use a mobile power source or operate from a 13.8 volt DC power supply. Power supplies are available commercially at surplus stores, and many excellent articles on building your own have been published.

Rather than build a separate +5 volt supply for the scanner, we borrowed a few mA from the +5 volt supply in the CB. Low-power components were selected to minimize the load on the existing CB radio power supply.

The scanner and control circuit requires only six integrated circuits and can be built on a 3 × 3 inch (7.6 × 7.6 cm) card. A diode encoder is used to program the operating frequencies. This gives the advantage of being able to select any of ten frequencies and more importantly, gives one a choice of crystals (frequency) to use.

A schematic diagram of the scanner section is shown in **fig. 1**. U1 is a decade counter with a built-in binary to decimal decoder. The outputs feed the diode encoder and indicator LEDs. The input to U1 comes from oscillator U2 (in the scan mode) or flip-flop U3A (in the single step mode). The other half of U3 is used to offset the frequency by 10 kHz. The frequency of the original CB is controlled by a Phase Locked Loop integrated circuit, or PLL IC. The diode encoder converts the ten decimal outputs from U1 to four control inputs to the PLL. The four control inputs cause the PLL to change its output frequency and the receive/transmit frequency of the radio. U4A is used to monitor the squelch of the radio and stop the scan when a signal breaks the squelch.

A type 555 oscillator (U2) is used to provide a scan step to the counter. The 7555 is a CMOS version of the 555 timer; its operation is identical except that the 7555 draws much less current. Radio Shack carries a TLC-555 which is also low current.

By Robert K. Baker, W2FMY, 263 Washington Avenue, Saugerties, New York 12477, and **Gary Bischoff KB2GA,** 1358 Charles Hommel Road, Saugerties, New York 12477

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The oscillator is cut off by grounding pin 4 or 5. Pin 5 is connected to S3, the SCAN/LOCK switch. Pin 4 is controlled by U4A, a comparator. When the radio receives a signal that breaks the squelch, the voltage at Q120 collector goes up, forcing the output of U4A low, stopping the oscillator. The other half of U4 is used to drive a "busy" light for visual indication when a signal is present.

The diodes at the input to the counter form an OR circuit so that inputs to either diode will step the counter. U3A is a debouncer for the STEP switch, which should be a push button or spring loaded toggle. U3A is used on an R-S flip-flop — even though it is a D-type device — by wiring the switch contacts directly into the Reset and Set inputs.

If S2 is closed, the output of U3B will be held in RESET state, forcing a logic zero to PLL control pin P0. Frequency coverage will be ten "even" frequencies — 29.50, 29.52 through 29.68 MHz. If S2 is open, U3B will be toggled by the end carry from the counter each time the counter counts ten pulses or wraps around. When the output of U3B is high, frequency coverage is shifted up 10 kHz to cover the "odd" frequencies of 29.51, 29.53 through 29.69. The circuit will alternately scan the even then odd channels while S2 is open. When the frequency is shifted up, the high level at U3 pin 9 turns Q11 on, lighting the +10 kHz LED.

The ten outputs from the CD4017 counter drive 10 LEDS in addition to feeding the encoder. Q1 through Q10 (and Q11) can be almost any general purpose NPN small signal transistor such as a 2N2222 or 2N3904. The 4.7 kilohm base resistors were chosen to provide about 1 mA of base current, which allows practically any transistor to be used. Note that there is only one dropping resistor (1K) used for the ten LEDs since only one LED is on at a time. The current for the LEDs comes from the 13.8 volt source.

A diode encoder is used to convert from a decimal number to the digital data required by the CB PLL chip to select different frequencies. **Figure 2** shows the encoder used with our selected output frequencies and crystal frequency.

Figure 3 shows a transmit offset circuit that can be added to obtain the −100 kHz offset required for repeater access. Two boards were built using the crystal switching scheme described by MacFarquhar and Grant. They worked fine, but the price of the 10.795 MHz crystal exceeded the price of the CB board. A simple circuit was therefore developed to make use of the existing counter U1 when working through a repeater. The circuit (**fig. 3**) consists of two cascaded timer circuits, where U5 is a one-shot enable for oscillator U6. When the microphone PTT switch is depressed, the voltage on the CB point 14 goes positive and is inverted by Q13. The resulting negative shift at the collector of Q13 is coupled via the 470 pF capacitor to a diode gate and to the input of U5. The negative spike at pin 2 triggers U5, allowing oscillator U6 to send five pulses to the CD4017 clock input via the diode, which becomes the third leg of the existing OR circuit. When the PTT switch is released, the negative going level change at CB point 14 is coupled through the 0.01 microfarad capacitor to the input of U5 and another string of five pulses is sent to the 4017 counter. The circuit is disabled for simplex operation by grounding pin 4 of U5.

The pulse rate of U6 is about 240 microseconds. It is enabled for about 1 millisecond by U5. The time that U5 enables U6 must be set carefully. When the entire scanner is operating, the pulse width of U5 can be trimmed by selecting the proper value for R_X. Use a potentiometer or a decade box and lower the value of R_X until four pulses are output from U6. The pulses can be counted by using the PTT switch and observing the LEDs. Note the value at which the pulses change from five to four. Raise the value of R_X until six pulses are observed. Note this value and install a fixed resistor for R_X that is about halfway between these two values. If the 0.005 μF capacitor is accurate R_X should be around 150 kilohm. A mylar capacitor should be used in this circuit.

frequency and crystal selection

The following explanation is provided to explain frequency control and how to use an available crystal. The CB Phase Locked Loop (PLL) was designed to operate in the range of 2.24 to 2.68 MHz. Attempting to operate the PLL outside this design range may require modification of the PLL lowpass filter.[3,4]

The present ARRL 10-meter FM band plan covers the range of 29.50 to 29.70 MHz. The national calling frequency is 29.60 MHz (similar to 146.52 on 2 meters). Repeater outputs are on 29.62, 29.64, 29.66, and 29.68, with their inputs 100 kHz lower on 29.52 through 29.58. 29.50 is used as another simplex frequency. The CD4017 decade counter forms the heart of the scanner and gives us access to all ten frequencies. The ten additional frequencies are obtained by using a flip-flop to program the low order bit on the CB's PLL. The ten "odd" frequencies are presently all simplex frequencies.

To see how a crystal is chosen, we start at the required output frequency and work backward. If, for example, 29.6 MHz is the output frequency selected, the PLL VCO is mixed with a 10.695 MHz crystal oscillator to generate the transmit frequency. Our 29.6 MHz target requires that the VCO operates at 29.60 + 10.695 or 40.295 MHz. This in turn is mixed with the third harmonic of another crystal oscillator (Q105 on

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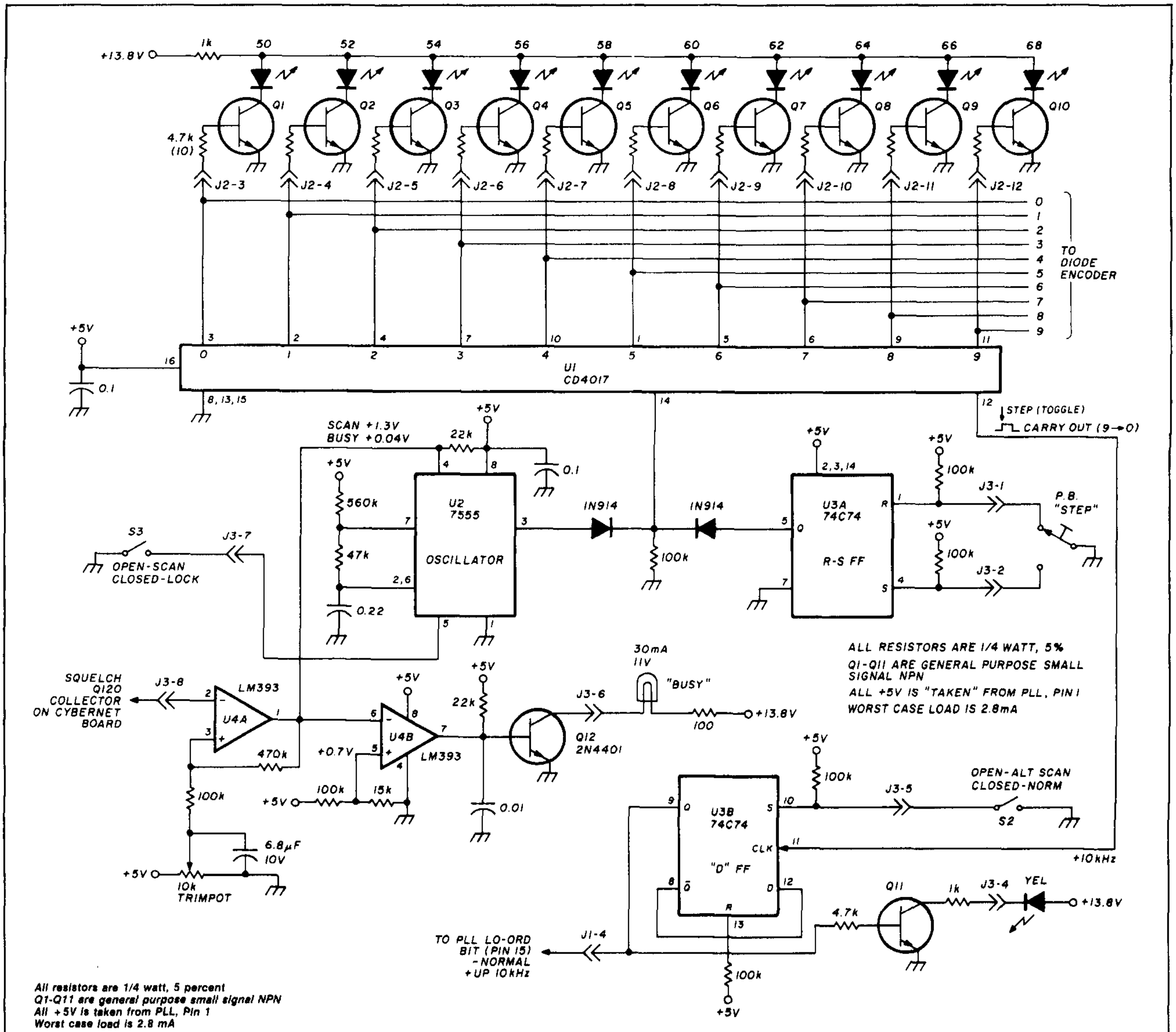


fig. 1. The scanner section only requires a few ICs.

the CB). The difference frequency is filtered and applied to the PLL. This frequency must fall in the range of 2.24 to 2.68 MHz.

When we started this project, we had about a dozen crystals left over from an earlier 10-meter club project. These crystals were marked 12.61333 MHz and had been ordered for a PLL using a reference frequency of 5 kHz rather than 10 kHz. The scheme we used required the crystal to operate up or down one third of a 5 kHz step or 1.67 kHz. We found the oscillator (Q105) more agreeable to being "rubbered" up than down, and had no trouble reaching 12.615 MHz. This frequency would have resulted in having to shift down to 10 kHz from 29.7 to reach 29.69 and not being able to use 29.50, which was clearly not desirable. By reducing C118 to 15 pF we were able to move the frequency up to 12.61833 MHz. Two units were built with crystals of 12.61833 MHz and they worked fine with the original value of C118.

The crystal's third harmonic of 37.855 MHz, when subtracted from the VCO frequency of 40.295 MHz, yields a difference of 2.44 MHz. To match at the 10 kHz PLL reference frequency, the PLL divider must divide by 244. The divide number is controlled by applying logic levels to the P0-P8 inputs of the PLL. Note that the PLL chip has internal pull-down resistors on these inputs. An open circuit is a logic zero, and a logic 1 is obtained by pulling an input up toward +5 volts.

We can develop a truth table based upon our choice of crystal. The P inputs of the PLL have binary "weights" with P0 having a value of 1, P1 having a

table 1. Truth table.

desired frequency (MHz)	VCO F (MHz)	mixer F* (MHz)	divider**	PLL program pin values								
				P8	P7	P6	P5	P4	P3	P2	P1	P0
29.50	40.195	2.3400	234	0	1	1	1	0	1	0	1	0
29.51	40.205	2.3500	235	0	1	1	1	0	1	0	1	1
29.52	40.215	2.3600	236	0	1	1	1	0	1	1	0	0
29.53	40.225	2.3700	237	0	1	1	1	0	1	1	0	1
29.54	40.235	2.3800	238	0	1	1	1	0	1	1	1	0
29.55	40.245	2.3900	239	0	1	1	1	0	1	1	1	1
29.56	40.255	2.4000	240	0	1	1	1	1	0	0	0	0
29.57	40.265	2.4100	241	0	1	1	1	1	0	0	0	1
29.58	40.275	2.4200	242	0	1	1	1	1	0	0	1	0
29.59	40.285	2.4300	243	0	1	1	1	1	0	0	1	1
29.60	40.295	2.4400	244	0	1	1	1	1	0	1	0	0
29.61	40.305	2.4500	245	0	1	1	1	1	0	1	0	1
29.62	40.315	2.4600	246	0	1	1	1	1	0	1	1	0
29.63	40.325	2.4700	247	0	1	1	1	1	0	1	1	1
29.64	40.335	2.4800	248	0	1	1	1	1	1	0	0	0
29.65	40.345	2.4900	249	0	1	1	1	1	1	0	0	1
29.66	40.355	2.5000	250	0	1	1	1	1	1	0	1	0
29.67	40.365	2.5100	251	0	1	1	1	1	1	0	1	1
29.68	40.375	2.5200	252	0	1	1	1	1	1	1	0	0
29.69	40.385	2.5300	253	0	1	1	1	1	1	1	0	1

1 = logic one (+5)
0 = logic zero (ground)

Note 1: Q105 oscillator 12.61833 MHz new crystal.
Note 2: Oscillator × 3 = 37.85499 MHz.

*2.680 maximum, 2.240 minimum.

$$**divider = \frac{(F_{OUT} + 10.695) - (3\ oscillator)\ MHz}{10\ MHz}$$

value of 2 and so on up to P8 with a value of 256. The frequency choice of 29.50 to 29.68 MHz works out so that P8 is always zero (floating), and the P5, P6, and P7 inputs are always logic 1, which we tied up to +5. To cover the desired frequencies, we need control only four inputs, P1 through P4. Since we have shown that the "divide by" number for 29.60 MHz is 244 and we are spacing our steps 20 kHz, it follows that 29.62 MHz would require two 10 kHz counts higher on 246. From the information that we now have, the truth table shown in **table 1** has been developed.

Examination of the table reveals that the P0 input is a logic zero for all of the "standard" 10-meter FM channels, which happen to be represented by even numbers. Switching the P0 input to 1 (+) shifts the PLL up 10 kHz to ten "in between" frequencies which are odd numbers — 29.51, 29.53, 29.55, etc.

Table 1 also shows the frequencies at the VCO output and the mixer output. Note that the mixer frequency must fall in the range of 2.24 to 2.68 MHz for the PLL to operate correctly. **Table 1** was derived from a spreadsheet program that does the mathematics involved with the crystal selection and frequency generation.† To check on the usability of a crystal, the user enters the crystal frequency and the highest output frequency desired; the program calculates the VCO output frequency, the mixer output frequency, the divider necessary to match the 10 kHz input to the PLL, and the PLL program pin values. The spread sheet is useful for demonstrating what is happening in the circuit as well as for crystal and frequency selection.

To build the encoder, replace each + in the truth table with a diode. No diodes are needed for the − points on the table because of the pull-down resistors in the PLL.

construction

The first step in building this radio should be to get the CB working as a CB. (The referenced articles cover this subject in detail.[2,3,4]) We took the additional step of inserting pins in the CB at the points where connections are to be made such as the speaker output, microphone input, and the volume and squelch potentiometers.

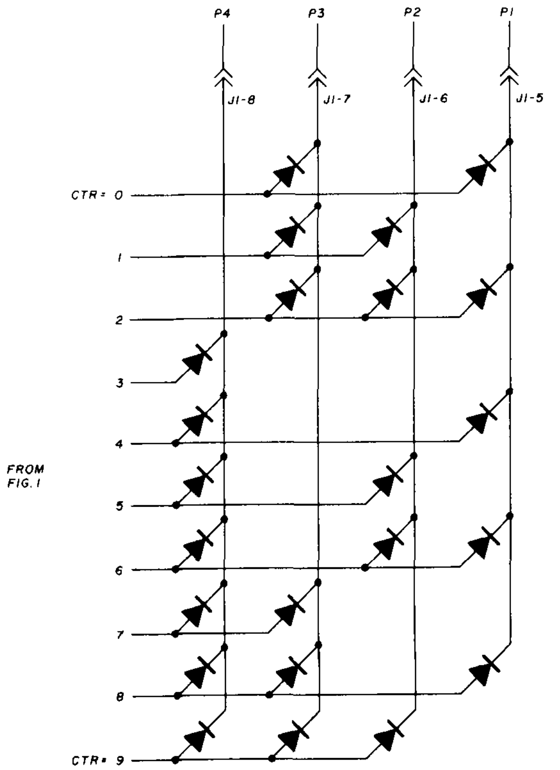
In addition to making the board easy to remove, we can interchange boards when problems arise. We found that the extra work was beneficial.

†A copy of the spread sheet, written in Lotus 123 and VisiCalc for an IBM PC and compatibles, or in VisiCalc for Apples, is available from the authors. Send an SASE for information.

The board used for the modification was made by Cybernet when the CB craze was in full swing. Cybernet manufactured these boards for several manufacturers such as Hy-Gain, Kraco, and others.

We found some CB boards with wrong value components. If the phase locked loop can not be made to lock by adjusting the VCO coil slug, check the value of R103 in the VCO circuit. The correct value is 1.5K, not 3.3K. Also, C101, which is buried in wax, should be 18 pF. (Some had a purple mark and measured 22 pF. If C101 is black, it's OK. This is apparently a production change that works on 27 MHz but doesn't work on the high end of 10 meters.)

We had a severe birdie problem on all 20 channels during tune-up of one of the first conversions that we built. The birdie was apparently caused by the 10.695 offset oscillator's being off in frequency. To prevent problems when the radio is being tuned up, all three oscillators must operate at the correct frequency. Radio Shack carries 3-10 pF trimmers (catalog No. 272-1338) that fit directly in the board; they are useful for adjusting the oscillators. Start with the 10.24 MHz reference oscillator. Loosely couple a frequency counter to the collector of transistor Q104. If the frequency is off, install a trimmer in location CT103 and try to move the frequency. C178 may have to be changed from 56 pF to a 39 or 43 pF capacitor. Set the frequency to exactly 10.24 MHz. To adjust the 10.695 MHz offset oscillator, connect the frequency counter to the emitter of Q109. Since the oscillator is not buffered, any appreciable capacitive loading will pull the oscillator frequency. We used a 10 to 1, low capacity oscilloscope probe to connect the counter. Install a trimmer in location CT102, and change C127 to a lower value. Adjust the CT102 for 10.695 MHz out with the transmitter keyed. Next connect the frequency counter to the dummy load at the output. Set up the P0-P8 PLL inputs to a known value such as 29.60 MHz and tune CT101 for the correct output, again with the transmitter keyed. If C118 must be changed, use the largest value that will permit CT101 to bring the oscillator to the desired frequency. This will make CT101 much less critical to adjust.



binary value	"P" No.	PLL pin No.	J1 pin
(16)	P4	11	8
(8)	P3	12	7
(4)	P2	13	6
(2)	P1	14	5
(1)	*P0	15	4

*Controlled by U3B on fig. 1.
Note: Inputs P5, P6, P7, and P8 are tied to Ground OR +5 for a combined weight of 224. See text for details.
All diodes (23) are 1N914 or equal.

fig. 2. The diode encoder converts a decimal number to the digital data required by the CB PLL chip.

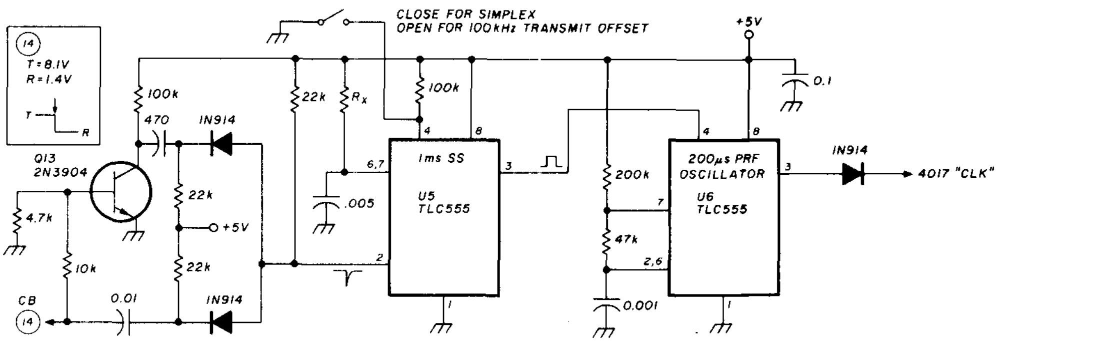


fig. 3. Digital 100 kHz transmit offset circuit.

conclusion

The scanner approach described above adds a new dimension to the CB-10 meter conversion by providing a simple yet versatile circuit. The digit offset control also has the capability of shifting up 100 kHz as well as down, in case you want to use the rig as a repeater — one local Amateur (Bob, W2XL) answered a call in the repeat mode and managed to work a station in Mexico.

In addition to the communication possibilities of a low power 10-meter FM rig, many local Amateurs use the radio to monitor 10 meters for isolated band openings. A dedicated rig eliminates the need to change frequency to check conditions; the radio is set up to monitor several repeaters. With the sunspot cycle on the decline, 10 meter openings are more sporadic, and when they occur, it's nice to know about them.

The circuits covered in this article can be used as shown or they can be used as a starting point for other innovative designs. There are other ways of obtaining the correct frequencies using a scanner approach such as using a decade counter and an adder to go directly into the PLL, which would make it easy to add the repeater offset. That may be a subject for a future article.

references

1. Ian MacFarquhar, VE3AQN, and Ken Grant, VE3FIT, "CB to 10 FM — One Group's Approach," *ham radio*, February, 1983, page 16.
2. Bob Heil, K9EID, "Experience 10-Meter FM Operation," *QST*, August, 1981.
3. J. Robert Witmer, W3RW, "Modifying a CB-Board Synthesizer for Amateur Use," *QST*, March, 1983.
4. Penn Clower, W1BG, "CB to CW? — Converting the HY-Gain Board," *73*, July, 1982.

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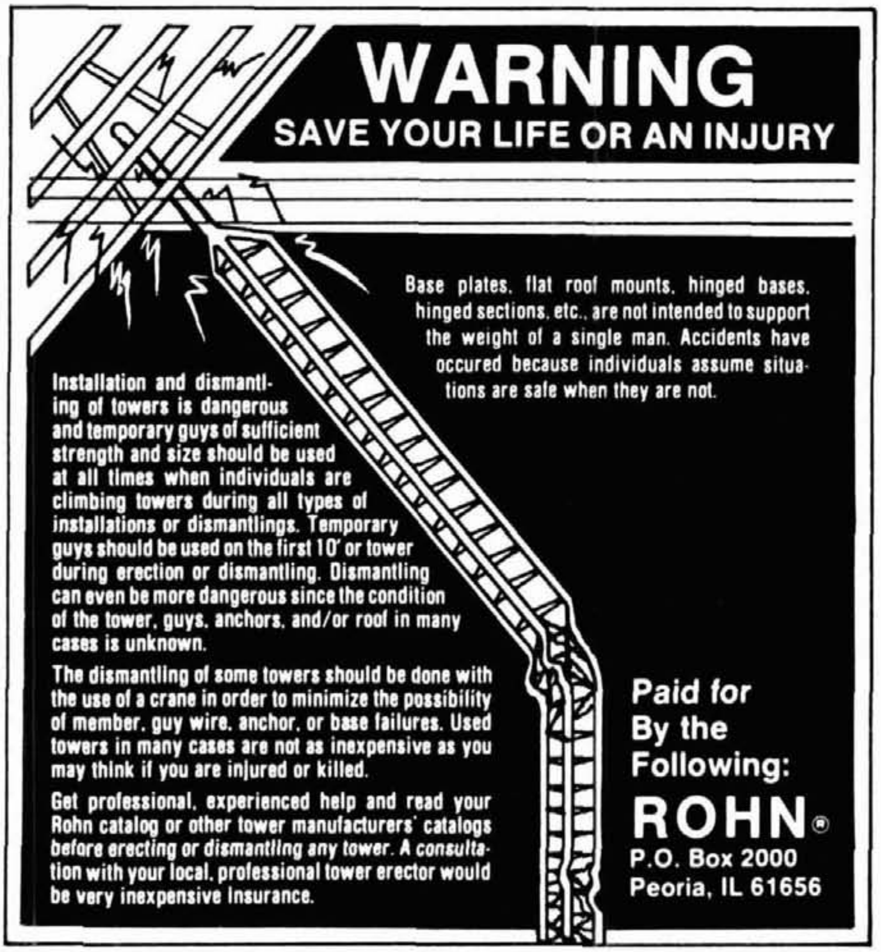

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Assembly and testing are straightforward. The only special equipment needed is a digital counter to set the oscilloscope and a 1 MHz heterodyne oscillator to the required frequency.

The construction and testing of each circuit should be done in the following order, completing each element before proceeding to the next:

- power supply
- audio amplifier
- VFO unit
- mixer-audio preamp (combined on board 3)

The power supply is a typical textbook assembly, with a three-terminal regulator. The bleeder R14 is used so that a constant load is placed on the power output at all times. To set the voltage, *before* AC is applied to the transformer, set R13 to the mid-point of the trimmer. Attach a voltmeter to the output point (at R14), apply 120 VAC to the primary of the transformer, observe the voltage at R14 and adjust trimmer potentiometer R13 to 12 volts. This circuit will need no further adjustments.

The assembly of the audio section has several important considerations. The TDA 2002 or TDA 2003 must have a 5-square-inch (12.7-cm^2) heat sink. A piece of aluminum 2 inches (5 cm) per side and 2-1/2 inches (6.35 cm) long was used to sink the device. The sink can be grounded to the B minus (and cabinet), providing a current return path for power and an adequate sink for device heat. Each module of the working model was assembled on a 3 × 4 inch (7.6 × 10.6 cm) vector board, with push-pin mounting for components and sockets for the transistors.

Keep all leads as short as possible. The 5 PC leads were soldered to push pins staggered in alternate rows. The assembled module was speaker tested with an audio oscillator and an oscilloscope with satisfactory results. The low-frequency cut-off was about 100 Hz and the upper range fell off after 6 kHz.

The local oscillator was assembled on a separate vector board using a standard Colpitts design. Note that the oscillator/mixer portions are FET devices, and consequently are high impedance circuits. To prevent loading down, the circuit testing was done with 10X scope (probe) leads.

frequency adjustments

To set the center frequency to 455 kHz, first set the C2 capacitor to its mid-point. Set C1, the compression trimmer, also to about its mid-point. Measure the oscillator frequency at the output end of C7 with the counter set to 1 MHz range. The coil, L1, should have a tuned resonance of 455 kHz ± 50 kHz. Adjust the slug in L1 to a point well before it extends beyond the wind-

By Alan Nusbaum, W6GB, 13222 Ballad Drive, Sun City West, Arizona 85375

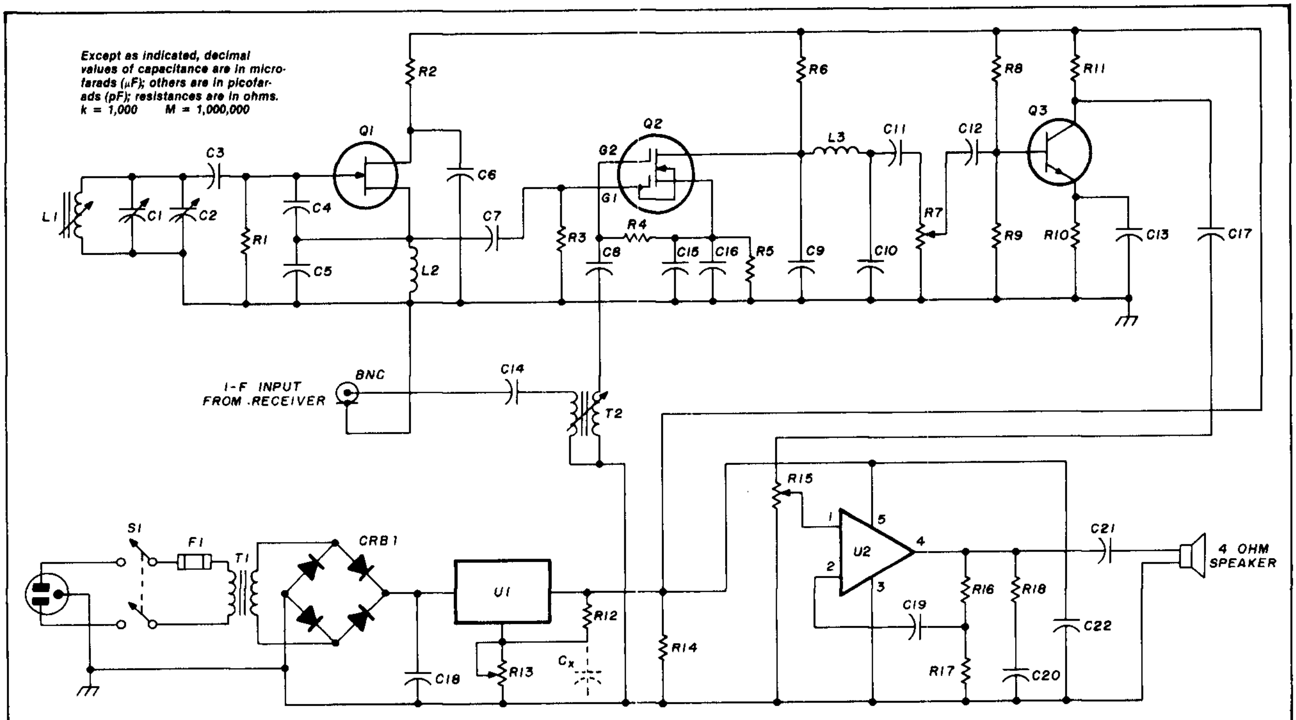

fig. 1. External product detector schematic.

Parts list.

item	description
BNC	BNC male, chassis mounting
C1	20-100 pF trimmer
C2	5-20 pF SFL ("butterfly") variable USB-LSB offset tuning
C3	390 pF, mica, 500 volt
C4	300 pF, mica, 500 volt
C5	500 pF, mica, 500 volt
C6	10 kilohm pF, ceramic, 50 volt
C7	100 pF, ceramic, 50 volt
C8	0.01 μF, ceramic, 50 volt
C9	1000 pF, ceramic, 50 volt
C10	5000 pF, ceramic, 50 volt
C11	1 μF, electrolytic, 50 volt
C12	1 μF, electrolytic, 50 volt
C13	50 μF, electrolytic,10 volt
C14	0.01 μF, ceramic, 100 volt
C15	10 pF, 10 volt ceramic
C16	10 kilohm pF, ceramic, 50 volt
C17	1μF, electrolytic, 25 volt
C18	4700 μF, electrolytic, 50 volt
C19	470 μF, electrolytic, 100 volt
C20	0.1 μF, electrolytic, 50 volt
C21	1000 μF, electrolytic, 50 volt
C22	0.1 μF, electrolytic, 25 volt
CRB1	MDA970-1 Motorola
Cx	5 μF, 25 volt if the leads from regulator causes oscillation as seen on an oscilloscope
F1	buss fuse, 1 amp, 120 VAC
L1	J.W. Miller No. 23A474RPC
L2	1.2 mH, Miller No. 73F123AF
L3	1.2 mH, Miller No. 73F123AF
Q1	2N5486 Motorola
Q2	3N201 Motorola
Q3	2N2222 Motorola
R1	100 kilohm, 1/2 watt
R2	100 ohm, 1/2 watt
R3	100 kilohm, 1/2 watt
R4	10 kilohm, 1/2 watt
R5	100 ohm, 1/2 watt
R6	1.5 kilohm, 1/2 watt
R7	100 kilohm trimmer, 1/2 watt
R8	91 kilohm, 1/2 watt
R9	22 kilohm, 1/2 watt
R10	150 ohm, 1/2 watt
R11	3.9 kilohm, 1/2 watt
R12	270 ohm, 1/2 watt
R13	5 kilohm trimmer, 1/2 watt
R14	2 kilohm W.W., 5 watts
R15	100 kilohm potentiometer, 1/2 watt
R16	220 ohm, 1/2 watt
R17	2.2 ohm, 1/2 watt
R18	1 ohm, 1/2 watt
S1	DPST toggle switch
T1	115 volt primary, 17 volt, 2 ampere secondary
T2	455 kHz Miller No. 8812
U1	LM317K National

Note: All resistors 5 percent

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ings, then fine tune by adjusting C1, while keeping C2 at its mid-range value. If leads have been kept short, the 455 kHz point should be found without difficulty. The open-air maximum drift as measured on a counter was less than 100 Hz at the end of 1 hour.

The oscillator output voltage through C7 was about 1.5 volts peak-to-peak, which is the required amplitude. If the voltage is greater than 1.5 volts, reduce the value of C7. The loading of this output by Q2 has negligible effect on the amplitude of the voltage.

A test for upper and lower sideband heterodyning is the most important aspect of a product detector circuitry.

With C2 set at its center point, the counter should still register 455 kHz. Adjust C2 slowly to a lower value of capacitance and frequency should increase to about 458 kHz. Move C2 to a higher capacitance (at the same excursion as above) and the frequency should drop to 452 kHz. Return the tuning to mid-point, 455 kHz. Turn off the power.

Install Q2 (3N201) in the socket. Connect a stable signal generator set to 455 kHz to the signal input BNC connector. The amplitude of the signal should not exceed 100 mV peak-to-peak sine wave, unmodulated. Connect the scope to the output end of C11, which is the top of trimpot R7. Power up the circuit and sync the VFO with the signal generator so as to display a null on the scope. Swing C2 through its upper and lower excursions, verifying that the waveform remains linear through sum and difference mixing of the signals. The amplitude should be about 200 mV peak-to-peak (3-dB mixer gain). Move the scope probe to the output side of C17. Adjust R7 trimpot for an output of less than 500 mV peak-to-peak. There should be no distortion of the output signal. If all components have been wired correctly, the Pi-section filter C9, C10, and L3 will have removed all mixer by-products with just the product of the two oscillators displayed on the scope. Increasing the signal generator output to 250 mV peak-to-peak should not cause distortion of the output signal. Be aware that the voice products of a product detector vary over the speech range and signal strengths. High signal amplitudes should not distort. A reduction of the R7 gain potentiometer will reduce large signal distortion.

The MOSFET, Q2, can tolerate high signal levels without distortion, however Q3 *can* be overdriven. A distorted signal is not pleasant to listen to.

After these tests have been completed, you're ready to assemble the power audio IC and hook up the R390A IF output connector.

The input and interconnect cabling was done with RG 217/U coax. The low frequencies of the system could have tolerated audio cords with equal success.

The builder can use edge card connect boards with matching sockets. This writer drilled holes in the vector board corners and fastened the boards with 4-40 screws and 1/2-inch (1.27 cm) aluminum spacers. It all works happily together and that's what it's all about.

modifying the R390A

Several changes can be made to improve sensitivity, and noise figure of the R390A receiver. The modifications are made to the IF module only.

Disconnect AC power to the R390A. The rear terminal board TB102 has a jumper between terminals 3 and 4. Disconnect this jumper and ground terminal 4 to the receiver frame. Connect a voltmeter between terminal 3 and ground. Carefully remove the aluminum shields covering T501, T502, T503, and Z503.

Drill 3/16 (0.476 cm) holes in the top center of these shield cans. Be sure to de-burr afterward since the aluminum is soft.

Inspect the IF transformer T501. Locate the resistors shunting the primary and secondary winding. *Caution:* The Litz wire connecting the inductors is very fragile and easily broken. The resistor values in my receiver were 47 kilohms but could be as low as 15 kilohms in other models. Clip out these resistors, and replace the shields and observe the AGC voltage. Switch the receiver on and set the function switch to AGC, note that the voltage measures approximately 28 volts in the 2 kHz selectivity position. When peaking T501, T502, T503, and Z503, the voltage should increase to 34 volts (minimum) if all tubes are working properly. Replace the jumper on the TB102 AGC line, connect the Product Detector Module and you'll discover that you have a hot SSB receiver that rivals anything built today.

using it in other receivers

The application of the Product Detector-audio assembly is not limited to the type of receivers discussed in the text. If the IF frequency is other than 455 kHz, (such as the R-388), then the local oscillator coil can be chosen to work with the required matching IF. Miller coils cover most of the wanted ranges; the builder can also wind a coil to the frequency of interest. The old Hallicrafters receivers, as well as the Hammarlund, National, and RCA of WW2 vintage can regain their vigor, providing the first local oscillator is stabilized. Don't scrap the old boat anchors just because they won't copy SSB or CW like some of the newer radios. Add this stand-alone module and find out how good it was all along!

The author has several R390A receivers in restorable condition, with the manuals. They are laboratory units, not military surplus. A QSL card to W6GB will get details. — Ed

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build a handy RF probe

Build it simple — or more complex, for increased sensitivity

An RF probe is a useful instrument to have around the shack — if you can find one that's sufficiently sensitive. This article will help you build your own, using solid-state Germanium or silicon diodes in simple circuits to provide the necessary sensitivity.

using diodes

Two principles must be understood in using diodes of all types: threshold of operation and detection sensitivity. Ideally, all diodes have a maximum sensitivity set by the diode equation:

$$I = I_S \{[exp.\ (qV/kT)] - 1\} \quad \textbf{(1)}$$

where I_S is the saturation current, which sets the threshold, q is the electron charge, k is Boltzman's constant, and T is the absolute temperature (room temperature is about 290 degrees absolute), and V is the voltage. The expression (q/kT) is extremely important in solid-state electronics and has a nominal value of 39. Its reciprocal is 0.026 volt.

The smaller the value of I_S, the larger the threshold voltage required with any of these devices.* With the germanium diode, the threshold will occur at an anode-to-cathode voltage in the range of 0.1 to 0.25 volt, and with the silicon diode, 0.5 to 0.75 volt.

In practice, an operating current level between 0.1 and 1 mA is selected to compare various devices. In normal operation, the anode-to-cathode voltage at which the chosen level of current flows controls the minimum sensitivity of a diode probe.

Measuring current as a function of voltage in solid-state diodes, one finds a two-to-one change in device current with approximately 0.018 volt change in applied voltage. This is the sensitivity needed (see appendix).

Using a diode having a low threshold and full incremental sensitivity, as it can be called can improve the minimum sensitivity of an RF probe to allow the measurement of voltages in the 100 to 500 millivolt range. (This is why hot-carrier diodes are important.) The simplest circuit for using a high-threshold-sensitivity diode is shown in **fig. 1**. The input capacitor is selected so that its reactance ($1/\omega C$) is small compared to the diode's apparent resistance, and not more than the source impedance of the signal source. The resistance value in the output circuit should be large compared to the diode resistance, which is approximately $0.026/I$ where I is in amperes. Such an RF probe can be used in some receiver alignment applications as well as many routine tuning problems, and it can be used with a sensitive analog meter or a digital voltmeter.

building a better probe

Reducing dependence on the threshold limitation results in better RF probes because of high inherent sensitivity of solid-state devices. To take advantage of this sensitivity, a fixed level of operating current must be introduced to overcome the threshold and then apply a signal voltage from a low-impedance source to achieve the current sensitivity solid-state devices are theoretically capable of delivering.

Possibly the easiest way to avoid the threshold problem is to use a transistor so that we can sense the current changes more easily. A circuit using the LM 334 controlled-current source is shown in **fig. 2**. An isolation resistance that reduces the voltage drop across the LM 334 to perhaps a volt and a half will separate the DC and RF circuits.

*The value of I_S is a function of the numbers of the charge carriers in undoped or intrinsic material. In undoped germanium, there are 1131 times as many carriers than in silicon. This leads to at least 0.180 volt more bias for the silicon diode than for the germanium.

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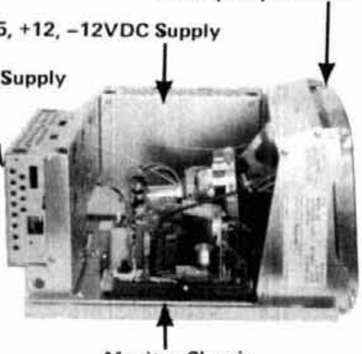

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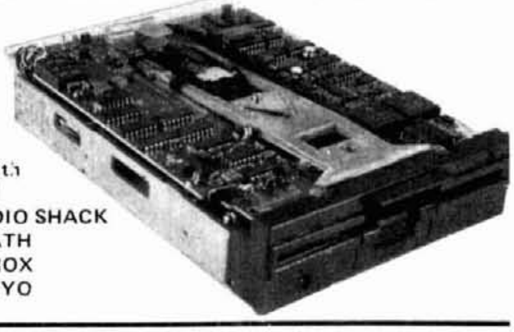

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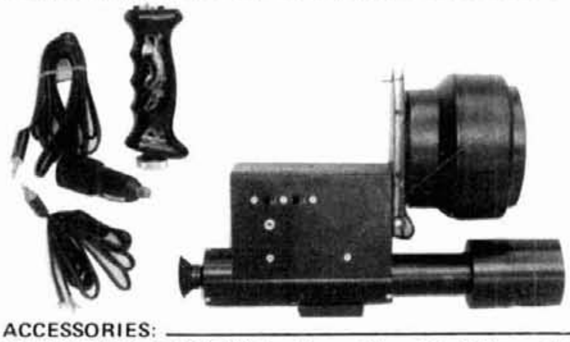

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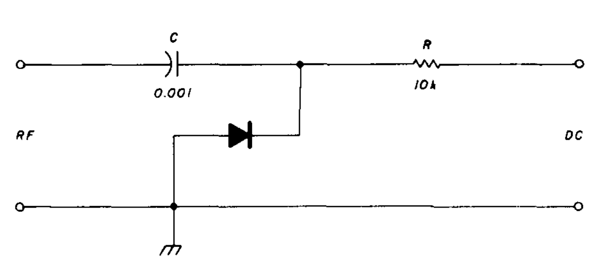

fig. 1. Simple probe. Note: resistor across RF terminals if needed.

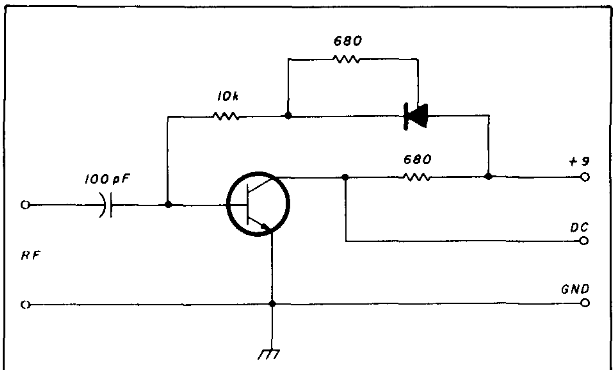

fig. 2. Sensitive probe using an LM334 controlled-current source.

A simple review of the principles underlying detection is included in the appendix.

The circuit shown in **fig. 2** works as predicted, but it still is not optimum because very small current changes must be observed if sensitivity is to be optimized. For this, a reference voltage follower can be used, (**fig. 3**), resulting in a voltage-sensitive bridge. Full-scale indication on the output meter with output changes of 100 millivolts (the full-scale reading of the meter) can be achieved easily. This may correspond to as little as 30 mV of RF signal. The scale will not be linear, but will approach a square-law function.

Using the meter directly between the collector circuit of the detecting transistor and the voltage reference will also reduce the sensitivity of the detector. Two circuits that can do this, both reducing the current load on the detector output, are shown in **fig. 4**.

The basic problems are now solved. To minimize the loading the detector places on the source, a situation that is particularly important if the RF source has high-impedance characteristics, VMOS transistors such as the VN10KM can be used as an amplifier. These transistors are better used as wideband amplifiers, with the output taken in the drain circuit. A small amount of degeneration through the use of a source resistance is acceptable, although it does reduce the amplification. In no case should the amplification exceed ten, and it may be as small as 1.0 to 1.5. A possible circuit is in **fig. 5**.

If greater sensitivity is required, a pair of high-frequency bipolar transistors can be used in a cascode arrangement after the VMOS transistor and before the input of the detection transistor to get an additional X10 voltage gain. A useful circuit for this is shown in **fig. 6**. This circuit should also be broadband. The output load resistance required will be approximately $260/i_C$, with collector current, i_C, measured in milliamperes. The resulting unit will have a voltage gain of roughly 10, and can be built quite easily. It will extend the minimum sensitivity down to about the millivolt level. These amplifiers limit with input signals over about 10 millivolts, and will also rectify, distorting the input signal.

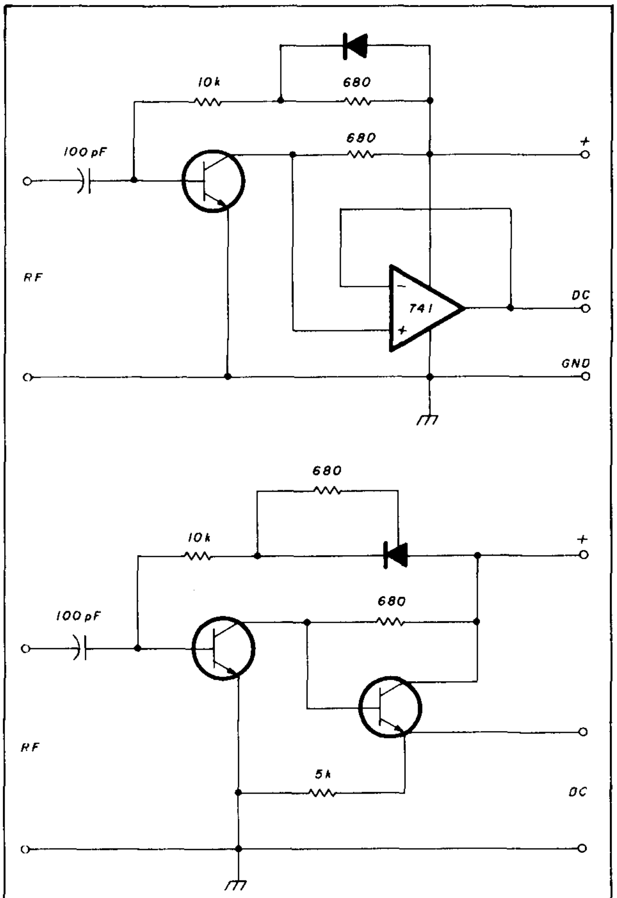

fig. 3. Two circuits that can be used to improve the sensitivity of the detector.

other applications

The buffered RF probe has a variety of applications of interest to Amateurs beyond its use in circuit testing. I have built one into a homebrewed Q meter, for example, and also into a low-frequency dip meter.

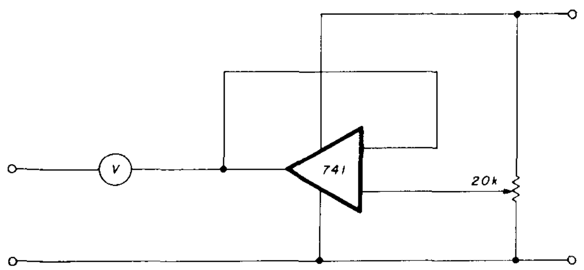

fig. 4. Circuit for a reference voltage follower to obtain a voltage-sensitive bridge.

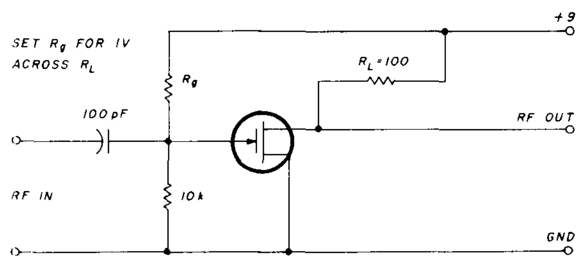

fig. 5. High-impedance preamplifier. Gain should not exceed 10 and may be as low as 1.0 to 1.5.

The buffer FET can be the VN10KM mentioned above. (I have described an instrument for testing FETs in *Design of Transistor Circuits, with Experiments*.[1]

The field-intensity meter uses the cascode amplifier operating into the transistor metering circuit. I did not use the FET here because I assumed that the dipole antenna, consisting of two collapsible TV antennas, would have essentially a low-impedance output. (A suitable loop may be used instead, however.) The unit seems to work quite well.

The low-frequency dip meter must use variable-inductance tuning because a variable capacitor of appropriate size for this application would be much too large, and smaller ones would have too high reactance. The basic oscillator circuit I used is based on an emitter-coupled amplifier with a variable LM 334 current source for the base drive on both transistors, **fig. 7**. The oscillation level is set with a potentiometer across the LM 334 control points, and magnetic coupling is used to test a circuit. I have arranged the assembly so that I can plug in a variety of slug-tuned coils; the coils have slugs on threaded rods with a short piece of piano wire soldered in the screw slot. The drive consists of a piece of quarter-inch brass rod drilled and slotted to engage the wire. The frequency change is slow and smooth.

I can also tap off RF output from the FET buffer for frequency counting or use as a signal source. This unit easily fills the gap between audio and 2 MHz, the lower limit on most dip meters. The actual circuit is a combination of **figs. 3**, **4**, and **7**.

The Q meter used the same metering circuit as the dip meter for measuring RF. The RF source I use is a conventional inexpensive signal generator, except that I have tapped in on it prior to its normal output stage. These deliberately generate distorted waveforms to create harmonics in the output. You may wish to put an FET buffer between the oscillator and the special output to ensure better frequency stability. A suitable circuit for this is shown in **fig. 8**. About 10 millivolts of RF are needed by the Q meter input circuit.

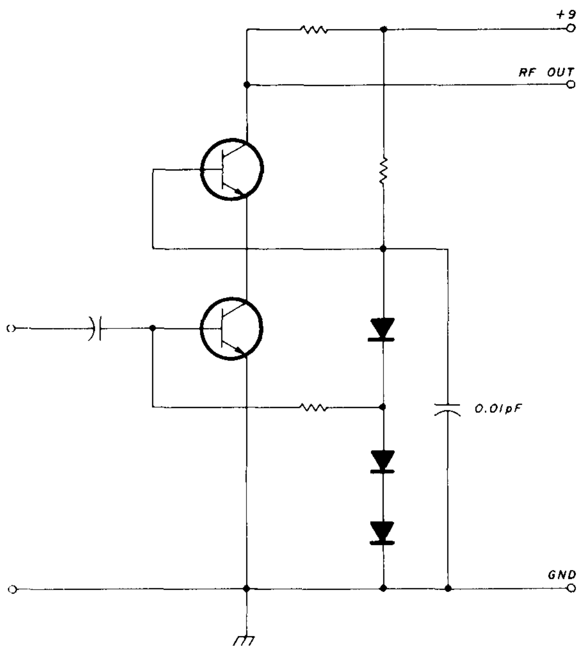

fig. 6. Cascode preamplifier with a voltage gain of about 10. Sensitivity is at the millivolt level.

The RF drive transistor that provides the RF signal to the measurement circuit should be a high-frequency bipolar transistor, and should provide a voltage gain of approximately 10 overall. (Only a hundredth of this is actually applied to the tuned circuit, 100 microvolts.) The full output is used to calibrate the circuit, and the part to control the tuned circuit. One is then matched against the other, based on oscilloscope calibration. A possible circuit is shown in **fig. 9**. Minimum Q sensitivity will be about 20. About 25 mA of collector current will be needed by the 2N2222 or 2N2369 to provide the required signal voltage. A Q test circuit is shown in **fig. 10**.

calibration

This calibration technique, done with an oscilloscope, can be used wherever minimum or maximum

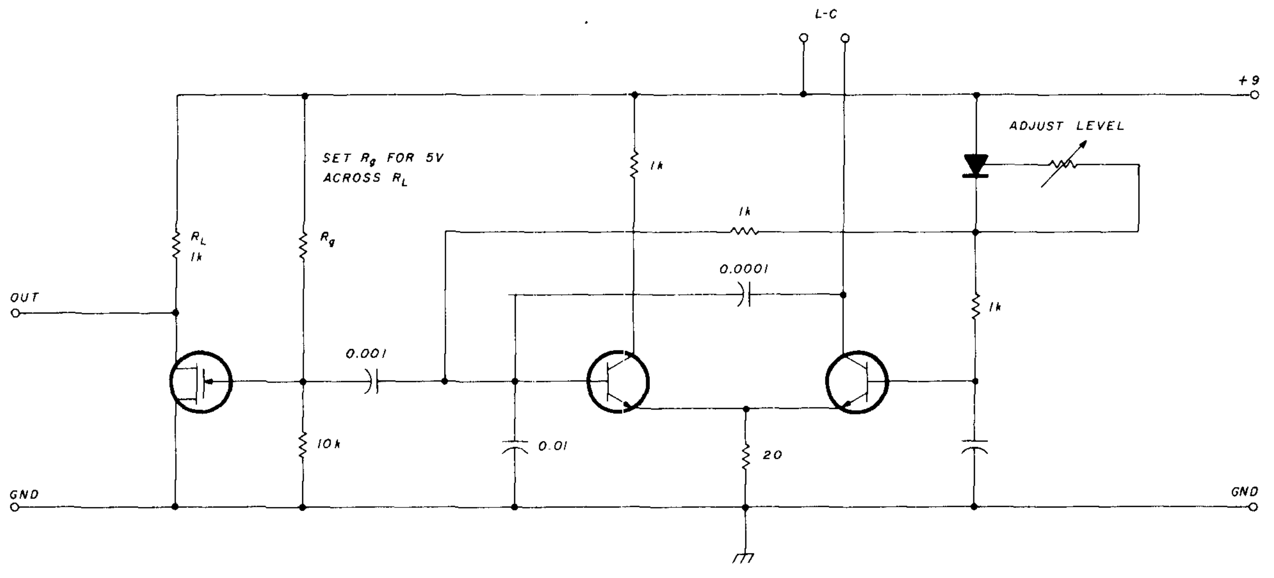

fig. 7. Oscillator for low-frequency dip meter.

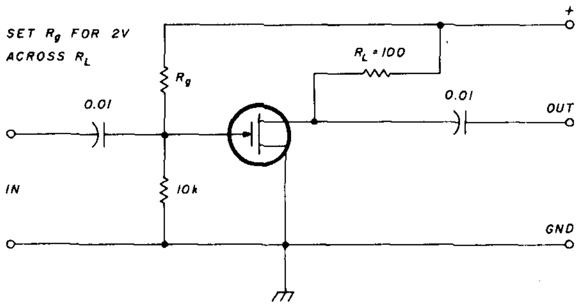

fig. 8. Buffer stage to ensure better frequency stability for Q meter use.

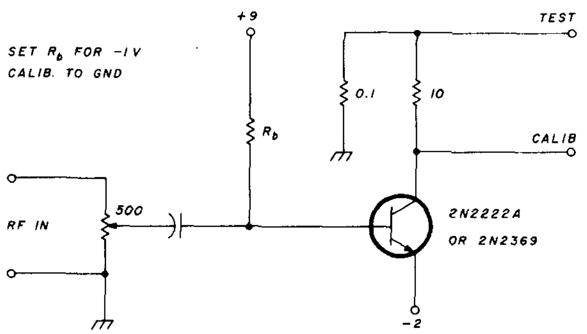

fig. 9. Q driver has a minimum sensitivity of about 20.

deflection is insufficient to assure proper circuit operation, but an actual voltage value is required. The oscilloscope can be calibrated with a reference voltmeter and an AC signal. RMS calibration should be used. The low-frequency calibration is used, with the help of the oscilloscope, to calibrate sinusoidal signal well within the upper limit of the oscilloscope (1/2 to 1 MHz for a 5 MHz unit). This calibration then is transferred to the Q meter measuring circuit. The source calibration voltage for setting the Q meter reference input may be adjusted for 20, 50, and 100 millivolts for the reference excitation. This will make possible measurements of Q to 100, 200, and 500. In addition, the meter is calibrated for a series of input signals ranging from about 10 mV to 100 mV, at least every 10 mV, to provide the actual Q measurement. A special scale may be made for the meter if desired. Since the Q is proportional to the RF voltage generated, calibration is important.

concluding remarks

These simple probe circuits can easily be built into transmitters, and receivers in which critical tuning is required as well as into other useful test instruments. In all cases, it is important to minimize probe loading on the circuit being tested without simultaneously degrading sensitivity. The VMOS circuits are ideal for this purpose, and they do not limit as readily as bipolar transistors. Where either germanium or silicon diodes can provide adequate sensitivity, they, of course, are the component of choice, but they do have the excessive threshold voltage requirement that the current-stabilized transistor circuits can help overcome.

RF measurements have always been a stumbling block in the typical Amateur station, including mine. I can remember building a nice wavemeter that I was

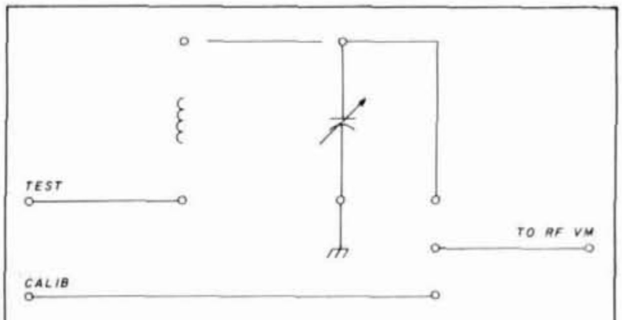

fig. 10. Q test circuit using an RF voltmeter. High-impedance input is used.

unable to calibrate. The described circuit techniques are a result of years of trying to solve similar problems inexpensively. Perhaps these ideas can help rekindle the experimental spark in other Amateurs, and help reverse the trend away from homebrewed equipment. *You don't have to be a mathematician or physicist to contribute to progress!*

reference

1. Keats A. Pullen, Jr., *Design of Transistor Circuits, with Experiments*, Howard W. Sams, Inc., Indianapolis, Indiana.

appendix

Rectification is a change in the effective resistance (of conductance) of a diode as a function of its applied voltage. This difference causes distortion, and it is the distortion of the current-voltage relationship that converts an AC signal into some level of change of average current and average voltage.

Strictly speaking, the relationship between the current and the voltage in a diode is nonlinear, or exponential. But for small voltages, it "looks" like a square-law device. The basic relationship can be stated in terms of the equation:

$$i = I_o \exp(qV/kT) = I_o [1 + qV/kT + (qV/kT)^2/2 + \ldots] \qquad \text{(A1)}$$

When V is set equal to $V_o \sin(2\pi ft)$, the relationship becomes, if $a = (q/kT)$:

$$i = I_o \{1 + aV_o \sin 2\pi ft + [a^2V_o^2 \sin^2(2\pi ft)]/2 + \ldots\} \qquad \text{(A2)}$$

The third term in the brackets on the right converts to the form:

$$(a^2V_o^2/4)(1 - \cos 4\pi ft)$$

and the DC term now is $(1 + a^2V_o^2/4)$. The term $a^2V_o^2/4$ represents the DC shift due to detection, and the current peaks in the two directions are:

$$I_o (1 \pm aV_o + a^2V_o^2/2) \qquad \text{(A3)}$$

The capacitor-input detector has a peak shift from $(1 + aV_o + a^2V_o^2/2 \times I_o$ to $(1 - aV_o + a^2V_o^2/2) \times I_o$. We filter out the $V_o \sin 2\pi ft$ and the $\cos 4\pi ft$ terms with the RC circuit. With the peak detector, the current change is $I_o (a^2V_o^2/2)$; this is what we wish to read.

From the above relationships, it is possible to show that with the *normal diode detector*, a current change of 2:1 can be obtained with 18 millivolts peak-to-peak signal on a diode, and a DC shift between 8 and 16 percent may be generated, depending on whether *square-law or peak detection* is selected. The signal distortion is roughly 8 percent.

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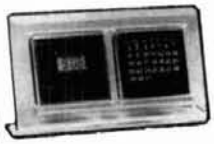

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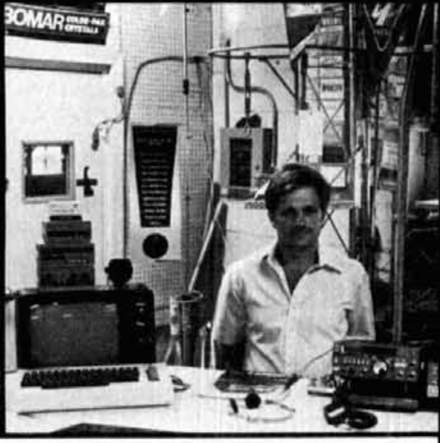

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product REVIEWS

Butternut HF-2V vertical antenna

About seven years ago, Butternut burst on the scene with one of the first "new" antenna ideas for the Amateur market. Their HF-5V was a five-band, no-trap antenna that covered 80-10 meters. I was one of the first to get one for review and was very much impressed with its performance. In head-to-head competition with comparable antennas, the Butternut always was at least one S-unit stronger during on-the-air tests. Owners of Butternut's current model, the HF-6V, have told me that it does equally well.

Recognizing that the six-band HF-6V was a little short for 80 and 40 meters and the fact that the high bands are going to be at best marginal for the next few years, Butternut modified their basic antenna design to optimize performance on 80 and 40 meters. The net result is the HF-2V antenna. The HF-2V incorporates all of the design features of the HF-6V — stainless steel hardware, T-6061 aluminium tubing, for strength and a double-walled base section for even more structural integrity and no traps.

the antenna

As with any antenna project, the first task was to read the instruction manual from cover to cover and take a full inventory of all the parts and hardware. All you need to assemble the antenna is a blade screwdriver, pliers, and a knife. A set of nut drivers would also be handy.

Assembly is straightforward and should only take an hour or so to accomplish. Identification of parts and hardware is easy if you use the schematic diagram that comes with the unit. The antenna is constructed of telescoping aluminum with sections held together with stainless nuts and bolts.

The antenna is loaded four feet from the base with an L/C combination made of very heavy duty aluminum wire and high voltage transmitting mica caps. Since the antenna is almost a full quarter wave on 40, very little of the 40-meter coil is used to tune the antenna. Should there be too much inductance for 40, a shorting strap is provided. The antenna is impedance matched at the base with an adjustable coil.

about radials

A lot of fuss is made about radials for vertical antennas and rightfully so. Many of those who install verticals constantly complain that the performance is less than was expected. In a majority of the cases, the prime reason is that there were either no radials or an insignificant number of radials under the antenna. In Butternut's opinion, it's best to assume that the earth you're working over is poor and that you'll need to engineer an artificial ground of your own. Radials can be either buried or laid atop the ground, whichever is easier. In general, it's better to install more short radials above ground than to lay just a few long ones. 16 50-foot radials will work rather well in most installations. The *ideal* radial system would include 120 resonant radials, 1/4 wave on each band. Needless to say, that is beyond the capabilities of most of us.

checkout and adjustment

Tune-up is simply a matter of adjusting the two loading coils for minimum SWR and adjusting the base impedance matching coil to correctly match the coax. As mentioned before, because the antenna is almost a full 1/4 wave on 40, very little inductance is needed to tune the antenna. To set up and tune it, you need to first short out a full seven turns of the 40 meter coil.

Now it's simply a matter of tuning the antenna for the lowest SWR on first 80 and then 40 meters. The next procedure is to attach the base step-up transformer and match the feedline to the antenna. This is a little trickier than it sounds, and took me more than a few minutes to accomplish. In order to get a proper match, you either expand or compress the coil to increase or decrease the inductance needed to get a proper match. I found that no matter how much I changed the coil, I couldn't get a proper match. Sometimes drastic measures are necessary; I used one here, reasoning that no matter how much I expanded the coil, I still had too much inductance to match the antenna. So I cut the coil in half, reattached it, and again applied power. The result was that the antenna was nearly matched and required only one minor change to complete tune up.

optional accessories and top loading

Butternut offers a number of accessories you can use to tailor the HF-2V to your own personal needs. As most low band operators will know, top loading antennas is a very practical way to make short antennas perform better. The top loading kit gives you four 25-foot stranded "umbrella" wires and insulators. The "umbrella" is designed to improve the overall antenna performance on 80 meters (and 160 with optional TBR-160 160-meter base loading kit). It will also improve the bandwidth of the antenna to over 100 kHz on 80 and approximately 35 kHz on 160 meters. Butternut also has a 30 and 20-meter resonator kit that can be added to the antenna. Unfortunately, you can only add one or the other, but not both.

operation

I've had this antenna up now for several months and have used it on both 80 and 75 as well as on 40 meters and have been quite impressed with its performance. On 80 the antenna has performed as well as my 1/4-wave sloper, and actually outperformed it in certain directions and conditions. When Ron Wright was on Tonga, A35EA, I was able to work him through a fair-sized pileup without too much difficulty. Not being a fan of 40 meters, my operating experience there is admittedly spotty. But this antenna has performed very well and I've been able to work just about everyone I called.

The Butternut HF-2V is the perfect antenna for those who want good low band performance without investing a lot of time and money installing a larger antenna. It's performance is comparable with a number of other antennas, and HF-2V owners will get years of excellent results with this antenna.

It's interesting to note that the recent DX'pedition by the Texas DX Society took a Butternut HF-2V to the island of Desescheo. Used with the optional TBR-160, it accounted for thousands of contacts on 80 and 160. The expedition members have reported that the antenna was a breeze to set up and performed flawlessly. I remember that during that operation, night after night, they came pounding through with perfectly Q-5 signals on 160.

specifications

weight	131 pounds/5.9kg
height	32 feet/9.75 meters
feedpoint impedance	50 ohms
VSWR at resonance	1.5/1 over a suitable ground
VSWR $< 2/1$	65 kHz on 80, full band on 40
power rating	2 kW PEP/1 kW CW (less with TBR-160)
wind no ice	80 MPH/125 kph when properly guyed

—de N1ACH

MFJ-204 antenna bridge

The MFJ-204 Antenna Bridge is designed to do three basic tasks: measure antenna impedance, measure resonant frequency, and to tune antenna tuners "off the air." It's a handy piece of test equipment that every ham should have. There are several reasons that an antenna bridge is a much more versatile tool than its cousin the noise bridge. The noise bridge is basically a wideband oscillator that can be used to roughly determine resonant frequency or impedance of an antenna. I say "roughly" because the wideband oscillator is difficult to use, is imprecise and can sometimes give misleading results. The antenna bridge, on the other hand, has a tunable oscillator that can be set to the precise frequency you want to work on. The MFJ 204 covers 1.6-2.5, 3-4, 7-11, and 13-30 MHz so you get full coverage of all HF Amateur Radio bands.

To measure antenna impedance, the first thing you do is set the oscillator to the frequency you want to work on. This is done by loosely coupling the antenna bridge to your receiver and listening for the beat note. You then connect the antenna bridge to the antenna to be measured and adjust the resistance control for a dip on the antenna bridge's meter. Once you get this dip, you flip the bridge over and read the resistance from the factory-calibrated chart on the back of the unit. On my 160 vertical antenna, I measured an impedance of 35 ohms, just about where it should be.

Using the antenna bridge to both measure resonant frequency and tune an antenna tuner is pretty much the same process. When used with an antenna tuner, the antenna bridge eliminates one of the most annoying aspects of the hobby — the ubiquitous and infamous "tuner-upper."

The MFJ 204 measures 2-1/2 × 2 × 7 inches and weighs just about a pound. It will run off a 9-volt battery or an optional 110-volt AC power supply. It's covered by the standard MFJ 12-month warranty and should give many years of good, reliable service.

I've since used the antenna bridge on several antenna projects and have enjoyed its utility. As long as I can keep the review unit, I think I'll let the noise bridge gather dust.

N1ACH

NEW products

computer interface

The Computer Patch Model CP-100 Interface is a complete terminal unit for Morse, Baudot, ASCII, and AMTOR. It will interface a computer running communications software via TTL levels (RS-232 optional) to your radio. With the optional current loop provisions, the CP-100 can be used with a mechanical teleprinter also. The tuning indicator is a ten-segment bargraph featuring discriminator-type operation which graphically shows selective-fading and is ideal for AMTOR use (tuning 'scope outputs are also

available). The CP-100 also features a front panel squelch control which inhibits data to the computer when no signal is present (thus preventing print when receiving noise). Front panel selec-

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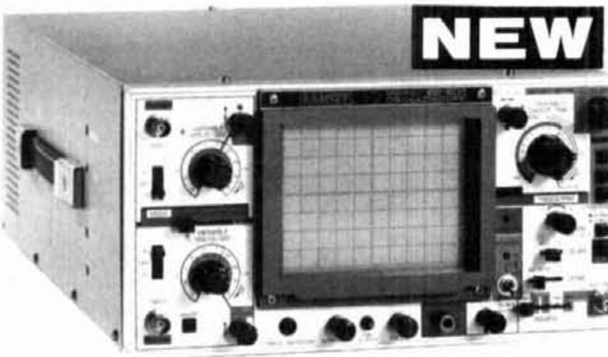

45 MHz DUAL SWEEP OSCILLOSCOPE

The Ramsey 625 is a dual time base, delayed sweep unit that includes a built-in signal delay line to permit clear viewing during very short rise times of high frequency waveforms. Other features include: variable trigger holdoff • 20 calibrated sweep time ranges from 0.5 s/div. to 0.2 μS/div. • fully adjustable sweep time • X5 sweep magnification • five trigger sources; CH1, CH2, LINE EXTernal and INTernal (V mode) • front panel x-y operation, Z axis input • sum difference of CH1, and CH2 waveforms displayed as single trace • sweep gate and sweep output • auto focus • single sweep. *USA — add $10.00 per unit for postage, overseas orders add 15% of total order for insured surface mail.

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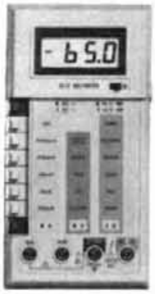

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More Details? CHECK—OFF Page 142

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tion of 110 and below or 300 baud operation is provided along with an internal monitor speaker. The CP-100 is housed in an attractive metal case, minimizing any potential RF interference efforts.

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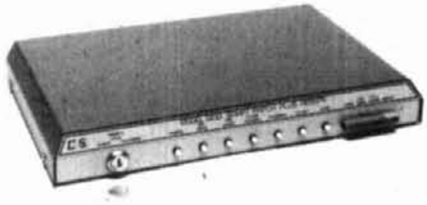

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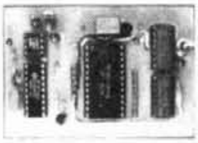

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DIGITAL AUTOMATIC DISPLAYS. All transceivers. Six 1/2" digits. 5" wide × 1-1/4" × 9" cabinet. Send $1.00 for information. Be specific. Grand Systems, PO Box 2171, Blaine, Washington 98230.

ANTIQUE RADIOS Schematics, tubes and literature. Send SASE to VRS (HR), 376 Cilley Rd., Manchester, NH 03103 for large list.

PRINTED CIRCUIT BOARDS TORCCC. Electronics will print any schematic, 6" × 9" maximum, on a circuit board for $1.50 (larger schematics – 0 add $1.25 per additional 50 square inches). Send check and schematic to: TORCCC Electronics, 2161 North California, Chicago, Illinois 60647.

WANTED: Regency XL2000 Transceiver or newer 10 channel 148-162 MHz or Wilson WH2510, PO Box 929, Blacksburg, VA 24060-0929. (703) 382-4458.

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NEW CODE SYSTEM. Curlycode, by W4BUP, lets beginners know code without "study", helps YOU boost your speed! Systems shows how sound patterns make unforgettable shapes in your minds-eye. Eight Curlycode shapes show most letters. Average of two different endings for each shape show all 61 characters. Booklet $6.50. Complete set: Booklet, wall chart, pocket card, special chart, all for $11.50. Discount 20 percent for 10 or more complete sets. Minds-eye Publications, Dept. H1, Box 1310, McLean, VA 22101.

THE GOOD SAM HAMS invite RV operators to check in the Good Sam Ham net 14.240± Sundays 1900Z also 3.880± Tuesdays at 2359Z. Net control N5BDN, Clarksville, IN.

SCHEMATIC: Radio receivers 1920's/60's. Send brand name, model No., SASE. Scaramella, PO Box 1, Woonsocket, RI 02895-0001.

CABLE TV CONVERTERS/DESCRAMBLERS. Jerrold, Hamlin, Zenith — many others. Factory units/lowest dealer prices. Complete illustrated catalog, $2.00. Pacific Cable Co., Inc., 7325-1/2 Reseda Blvd., Dept. 1006, Reseda, CA 91335. 818/716-5914.

NEW VLF 2 kHz-500 kHz products by K1RGO. L-101B VLF converter, L-201 VLF broadband preamplifier, L-400 VLF active antenna and more. Write for free catalog. LF Engineering Co., 17 Jeffry Road, East Haven, CT 06512.

ICOM AND KENWOOD SEPARATE NEWSLETTERS: 5 years of back issues! Now available TS930S & 430S users modifications supplement. Send 39¢ SASE for 12 page FREE Brochure to: International Radio, Inc., 1532 SE Village Green Dr., Suite L, Port St. Lucie, FL 33452.

HELP: Need schematic for Knight 2-meter transceiver Model TR-108. Will pay for copy. Ph. (209) 626-4219. KB6JDT, Donald M. Cox, 318 Park Blvd., Orange Cove, CA 93646.

SIGNAL GENERATORS, URM-25D, 10 kHz thru 50 MHz $245.00, URM-26B, 4 MHz thru 405 MHz $245.00, HP614A, 900 MHz thru 2100 MHz $345.00, HP618B, 3.8 GHz thru 7.6 GHz $375.00, HP608C 10 MHz thru 480 MHz $345.00, TS-510/U 10 MHz to 420 MHz $295.00. All lab calibrated. Have good stock so order today. We accept M/C, VISA, or check. FOB Otto. Immediate shipment. Phone Bill Slep 704-524-7519. Slep Electronics Company, Highway 441, Otto, NC 28763.

CABLE TV CONVERTERS & EQUIPMENT: Plans and parts. Build or buy. FREE information. C&D Electronics, 626 Flowerdale, Dept. HR, Ferndale, MI 48220.

TR-7 USERS: NB-7 Noise blanker (new) $65.00 ppd. HS-75 headset (padded) new $14.00 ppd. SL-300, SL-500 CW filter $55.00 ea. ppd. K3UKW, Tony Musero (215) 271-8898.

FOR SALE: Kenwood TR-7800 two meter transceiver $200.00/offer; Regency & Hallicrafters 150-174 MHz receivers $15.00 each; Realistic SSB/AM CB $75.00. WB9YBM, Klaus Spies, 8502 Oketo, Niles, Illinois 60648.

ELECTRON TUBES — Radio & TV types 75% off list price — huge inventory! Also industrial types. Send for Free Catalog today or call Toll Free (800) 221-5802. Box HC, Transleteronics, Inc., 1365 — 39th Street, Brooklyn, NY 11218. See our display ad this issue.

IMRA, International Mission Radio Association helps missionaries. Equipment loaned. Weekday net, 14.280 MHz, 2-3 PM Eastern. Eight hundred Amateurs in 40 countries. Brother Frey, 1 Pryer Manor Road, Larchmont, New York 10538.

ELECTRON TUBES: — Receiving, transmitting, microwave . . . all types available. Large stock. Next day delivery, most cases. Daily Electronics, PO Box 5029, Compton, CA 09224 (213) 774-1255.

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CUSTOM MADE embroidered patches. Any size, shape, colors. Five patch minimum. Free sample, prices and ordering information. Hein Specialties, Inc., Dept. 301, 4202 N. Drake, Chicago, IL 60618.

CX7 REPAIRS. 415-549-9210.

RTTY-EXCLUSIVELY for the Amateur Teleprinter. One year $10.00. Beginners RTTY Handbook $8.00. PO Box RY, Cardiff, CA 92007.

TRS-80 Model I/III/IV OWNERS. HF antenna design program calculates dimensions for dipole, yagi, and quad antennas. $14.95 (cassette) + $2.00 s&h to Cynwyn, Dept. H, 4791 Broadway, Suite 2F, New York, NY 10034.

OLD RADIO transcription discs wanted. Any size, speed. W7FIZ, Box 724 HR, Redmond, WA 98073-0724.

RUBBER STAMPS: 3 lines $4.50 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

RF DESIGN PROGRAM calculates stability, gain, noise figure circles, and more. For C-64 and IBM-PC, $29.95. Jim Allyn, N7JA, 7000 Litchford Road, #26, Raleigh, NC 27609.

AMATEUR RADIO CLASSES: Chelsea Civil Defense will sponsor evening classes at Chelsea High School starting October 16, 1985, for Novice (basic level ham license), and Tech/General licenses. Minimal cost for materials only. For information: Frank Masucci, 136 Grove Street, Chelsea, MA 02150.

NEW! CW WORD COPYING COURSE Complete. Easy-to-learn. QSO-Trainer™ code course. Includes two 60-minute audio cassettes and complete instructions. Send $16.95 (Indiana add 85 cents). Money back, satisfaction guarantee (less $2.00 shipping and handling). Business-size SASE gets free information. AVC Innovations, Inc., Dept. HC2, PO Box 20491, Indianapolis, IN 46220.

UHF PARTS. We stock GaAs Fets, trimmers, and many of those impossible to find parts for the UHF builder. For example: MGF 1202 at $10.00, Finger Stock at $7.50 per 16" strip. SASE brings list. Microwave Components, 11216 Cape Cod, Taylor, Mich. 48180

SELL: TS147A Test Set. 8.5-9.6 GHz CW-FM generator, frequency meter, power, manual. $50.00 plus UPS. Huntley, W6RNC, PO Box 478, Nevada City, Calif. 95959.

COMPUTERIZE YOUR IC-720 or R-70 Keyboard frequency entry, 64 memories, scanning (frequency, memory, and mode). Many more features. Requires no interface, just cable — directions included. For Commodore 64. Cassette $14.95, disk $16.75, ppd. Cables also available. David Oliver, W9ODK, Rt. 2, Box 246, Shevlin, MN 56676.

WANTED: Operations manual schematic for Sierra 305 A-L frequency selective level meter. Weber, 2605 West 82nd Place, Chicago, IL 60652.

WANTED: Old tube HiFi equipment. Working or not, complete or parts. All makes and models. Jack Smith, 59 Millpond, N. Andover, MA 01845.

RECEIVERS: Good operating and appearance with manual. HA-350, $50.00; NC-173; NC-300 $100.00 each. All plus shipping. Lisains, 116 Orton, W. Caldwell, NJ 07006. (201) 226-7943.

FREE 3 month subscription. Send callsign to Westlink Report-H11, 28221 Stanley Court, Canyon Country, CA 91351. New only!

KT5B ANTENNA 160m-10m no traps. $59.95. Weather Boot Kit $8.95. Open-wire, roller-inductor, antenna accessories and much more. Kilo-Tec, PO Box 1001, Oak View CA, 93022. Tel: 805-646-9645.

WANTED: R-1490/GRR-17 receiver, parts and manual. Gene Mottern, 313 Royal Drive, Kingsport, Tenn 37663.

2 METER AMP KITS: 8877 legal limit kit $395. 3CX800A7 900W kit $325. Also HV power supplies, CX600N relays, parts and EME newsletter. SASE for catalog. 2 Meter EME Bulletin, 417 Staudaher St., Bozeman, MT 59715

COMING EVENTS

Activities — "Places to go . . ."

GEORGIA: Southnet II Packet Radio Conference hosted by Georgia Tech Amateur Radio Club and sponsored by the Georgia Radio Amateur Packet Enthusiast Society. November 23 and 24, Georgia Tech campus downtown Atlanta. Tech sessions 8:30 to 5:00 Saturday and 8:30 to 12 Noon Sunday. For further information: Bill Crews, WB2CPV, 1421 Hampton Ridge Road, Norcross, GA 30093. (404) 923-1978.

MASSACHUSETTS: The Honeywell 1200 Radio Club and the Waltham Amateur Radio Association will hold their annual Amateur Radio and electronics auction, Saturday, November 23 at the Honeywell Plant, 300 Concord Road, Billerica. Doors open 10 AM. Free admission and parking. For more information: Doug Purdy, N1BUB, 3 Visco Road, Burlington, MA 01803.

ILLINOIS: Waukegan Squadron Civil Air Patrol will hold its annual Fall Hamfest, Sunday, November 3, Lake County Fairgrounds, Rt. 120 and 45, Grayslake. Doors open 7 AM. Admission $3.00. Tables $5.00. Large indoor area, cafeteria, free parking. For further information and reservations SASE to CAP, 637 Emerald St., Mundelein, IL 60060.

COLORADO: AMSAT will hold its third annual Space Symposium in Vail, November 9. AMSAT has issued a call for papers to be presented at the symposium. Topics may include those of interest to Amateur Radio Satellite enthusiasts. Abstracts may be sent to AMSAT, PO Box 8005, #281, Boulder, CO 80306. For further information: Molly Hardman, N3CHZ, Chairperson, (303) 939-9334 or AMSAT Headquarters (301) 589-6062.

MINNESOTA: The annual Handi-Ham Winter Hamfest, Saturday, December 7, Eagles Club, Faribault. Registrations 9 AM. Handi-ham auction of equipment, dinner at noon followed by a program. Talk in on 19/79. For information: Don Franz, W0FIT, 1114 Frank Avenue, Albert Lea, MN 56007.

NEW JERSEY: The 4th annual Jersey Shore Ham/Computer/ Electronics Flea Market, November 3, 9 AM to 3 PM, Neptune City Recreational Hall, Neptune City Shopping Center, Neptune. Admission $3.00. Children under 12 and XYL's free. Refreshments available. Table $6.00. Tailgating $3.00. Send payment and SASE to Jersey Shore Hamfest, PO Box 192, West Long Branch, NJ 07764. Talk in on 147.045 and 146.52 simplex. (201) 222-3009.

LOUISIANA: The Twin City Hams are sponsoring a Hamfest, Saturday, November 9, West Monroe Convention Center, North 7th Street, West Monroe. 9 AM to 4 PM. Free swap tables. Amateur Radio exams will be given. Talk in on 146.52 simplex and 146.25/146.85. For more information: Benson Scott, AE5V, 107 Contempo Street, West Monroe, LA 71291.

MASSACHUSETTS: The MIT UHF Repeater Association and the MIT Radio Society offer monthly Ham Exams. Novice through Extra. Wednesday, November 20, 7 PM, MIT room 1-134, 77 Mass Ave., Cambridge, MA. Reservations requested 2 days in advance. Contact Ron Hoffmann at (617) 253-5820/ 646-1641. Exam fee $4.00. Bring copy of current license, two forms of picture ID and completed form 610 available from FCC in Boston (223-6609).

WISCONSIN: The Milwaukee Repeater Club is proud to sponsor the "6.91 Friendly Fest" on Sunday, November 24, Serb Hall, 51st and Oklahoma. Bring your swapfest bargains and sample good food and beverages. Also bowling. Tickets $3.00. 4' tables $4.00. Save $1.00 — SASE with payment to Milwaukee Repeater Club, PO Box 2123, Milwaukee, WI 53201 before November 11. Talk in on 146.31/91 and 146.52.

ILLINOIS: The Chicago Amateur Club will hold its annual Ham Auction, November 6, 7 PM to 10 PM, Edgebrook Golf Course Field House, 6100 N. Central Ave., Chicago. For information: (312) 545-3622.

INDIANA: The Allen County Amateur Radio Technical Society's 13th annual Fort Wayne Hamfest, Sunday, November 10, 8 AM to 4 PM, Allen County Memorial Coliseum, Coliseum Blvd., US 30. Indoor tables available $8.00. AC power extra. Premium tables with AC $20.00 each. Admission $3.50 advance. $4.00/door. Children under 11 free. Ladies' activities, forums, banquet Saturday night. Nearby motels and restaurants. VE exams Saturday, November 9 advance registration only. Talk in on 146.28/88. For information or reservations: ACJ-ARTS Hamfest, PO Box 10342, Fort Wayne, IN 46851.

MICHIGAN: The Oak Park High School Electronics Club presents the 16th annual Swap N Shop, December 1, Oak Park High School, Oak Park, 8 AM to 4 PM. Admission $2.50. After 12 Noon $1.50. All 8' tables $8.00. SASE to Herman Gardner, Oak Park High School, 13701 Oak Park Blvd., Oak Park, MI 48237 or call (313) 968-2675.

OHIO: The Massillon ARC will sponsor "Auctionfest 85", November 24, Missillon K of C Hall, off Rt. 21, 8 AM to 5 PM. Sellers setup 7 AM. Admission $2.50 advance and $3.50 at the door. Tables available at $7.00 per 8' space. Refreshments and sit down dinner. Free parking. Auction 11 AM. Talk in on W8NP, 147.78/.18. For advance registration and information: MARC, PO Box 73, Massillon, OH 44646. SASE please.

NEW YORK: 7th annual "Ham-Central", Sunday, December 1, Main Hall, Lutheran School, Moriches Road, St. James, Long Island, close to NYC. Doors open 7:30 AM for sellers/dealers. 9 AM general public. Table space $10.00/8' includes two free admission tickets. General admission $3.00. XYL and kids under 12 free. Seminars plus ARRL and AMSAT. Food and refreshements available. Nearby shopping malls and historic sites. Talk in on 144.550/145.150 and 146.52 MHz. For reservations and information call after 6 PM Bob Yarmus, K2RGZ (515) 981-2709 or Andy Feldman, WB2FXN (516) 928-3868.

FIRST US YL WINS SWEDISH AWARD. Emily Maytan, AC2V, of Yonkers, NY, has become the first American YL to win the "100-SM" award for confirmed contacts with 100 Swedish hams. Only 659 other hams worldwide have previously won this award.

OPERATING EVENTS — "Things to do . . ."

The Armored Forces Amateur Radio Net (A.F.A.R.) will operate from 0000Z November 10 to 2400Z November 11 to commemorate Veterans' Day 1985. Phone 80, 40, 20, 15 meters. CW on 40 meters. Certificate available for contact with member station. Send #10 SASE to WB1DWR #90, 16 Berkeley Circle, Newington, CT 06111.

The Royal Jordanian Radio Amateur Society has announced plans for JY50, a two week celebration marking the 50th birthday of His Majesty, King Hussein, JY-1 starting November 7 through November 21. For the special "Worked JY50 certificate" send copies of log and either 10 IRC's or $5 (US) to the Royal Jordanian Radio Amateur Society, JY50 Celebration, PO Box 2353, Ammann, Jordan.

THE GUERRI REPORT

Ernie Guerri W6MGI

new components and techniques for RF designers

When manufacturers offer new equipment, the resulting design is a complex function of expected market, engineering hours, and the availability of necessary technology and components. Fortunately for designers of RF equipment, new components are rapidly being developed to keep pace with the boom in telecommunications.

Among the more exciting developments in the semiconductor industry is the emergence of commercial Gallium Arsenide (GaAs) ICs. Both analog and digital functions are being implemented. The digital functions — prescalers, counters, memories, and shift registers — are capable of operation at 2 to 3 GHz, allowing the design of phase locked loops and frequency synthesizers at low microwave frequencies using only a few chips. The required interstage amplifiers are now also available as off-the-shelf GaAs IC amplifier blocks (Microwave Monolithic Integrated Circuits, or MMICs) covering octave (2:1) bandwidths with 10 to 30 dB of gain. These gain blocks are available from 50 MHz to over 18 GHz. Prices are high right now but we can expect dramatic reductions as sales volume increases.

In the realm of discrete devices, the High Electron Mobility Transistor (HEMT) is just now ready to emerge commercially. This improved class of GaAs FET can provide noise figures of about 1 dB at almost 10 GHz, with 8 to 10 dB of gain! Several companies have developed low-cost ICs based on HEMT concepts which would integrate large portions of complex microwave receivers into a single chip.

One of the most fundamental concepts in modern telecommunications is frequency translation, or mixing. Most receivers and transceivers have several conversions from one frequency or band to another. An important characteristic of the translation device is its ability to minimize the generation of unwanted products. Mixer development has now advanced to the point where we have image rejection mixers (the image is automatically suppressed by about 20 dB) well into the microwave region. There is a similar class called "termination insensitive mixers" that perform well even with highly reactive loads. The development of complex GaAs MMICs will soon permit the implementation of active frequency converters with high dynamic range, selectable image characteristics, and conversion "gain" instead of an insertion loss. We should see these devices — up to 4-5 GHz — readily available in the not-too-distant future.

Plain old resistors and capacitors are taking on a new look. Chip- and surface-mounted components with superb characteristics well into the microwave region are now available. The fact that most modern circuits operate at low voltage and power levels means that spacings and insulation can be very small. This in turn reduces the overall size of the component, and hence its parasitic inductance and capacitance. This trend will continue to provide more components with nearly perfect RF characteristics in the VHF/UHF and low microwave ranges.

Even coaxial cables continue to undergo substantial improvement. Semi-rigid coax with foil shielding, foam dielectric, and non-contaminating jacket is available at very affordable prices. This type of cable is usable to 500 MHz with losses of less than 0.1 dB/meter. Small diameter hardline is now available to the UHF/Microwave enthusiast on the surplus market, thanks to the huge quantities used by military and cable TV applications. These cables are nearly the ultimate in transmission lines; they boast very low losses well into the microwave region, 100 percent shielding, and closed-cell foam insulations with permanent water intrusion barriers. Properly installed, these cables can have a useful life of more than 20 years.

Some of the least heralded advances in component design have taken place in the realm of interstage filters. Multipole ceramic and crystal filters with flat passbands, steep skirts, and low spurious responses have become available at remarkably low prices. Made for virtually all of the standard IF frequencies (455 kHz, 10.7, 21.4, 30, and 45 MHz), these marvelous filters, buried deep in our equipment, give us selectivity and freedom from unwanted responses that would have been a dream just a few years ago.

The advances continue. Monolithic crystal filters with narrow bandwidths (5-15 kHz) have been fabricated at over 250 MHz. Surface Acoustic Wave (SAW) filters with good characteristics up to 1.5 GHz are now available commercially. The availability of these higher frequency filters means that next-generation equipment can use up-conversion (IF higher than the incoming signal) to give us image-free, single conversion (large dynamic range) performance.

As the spectrum becomes more intensely populated, we are fortunate that component designers and manufacturers are investing in the technology to assure that there will be room for all of us.

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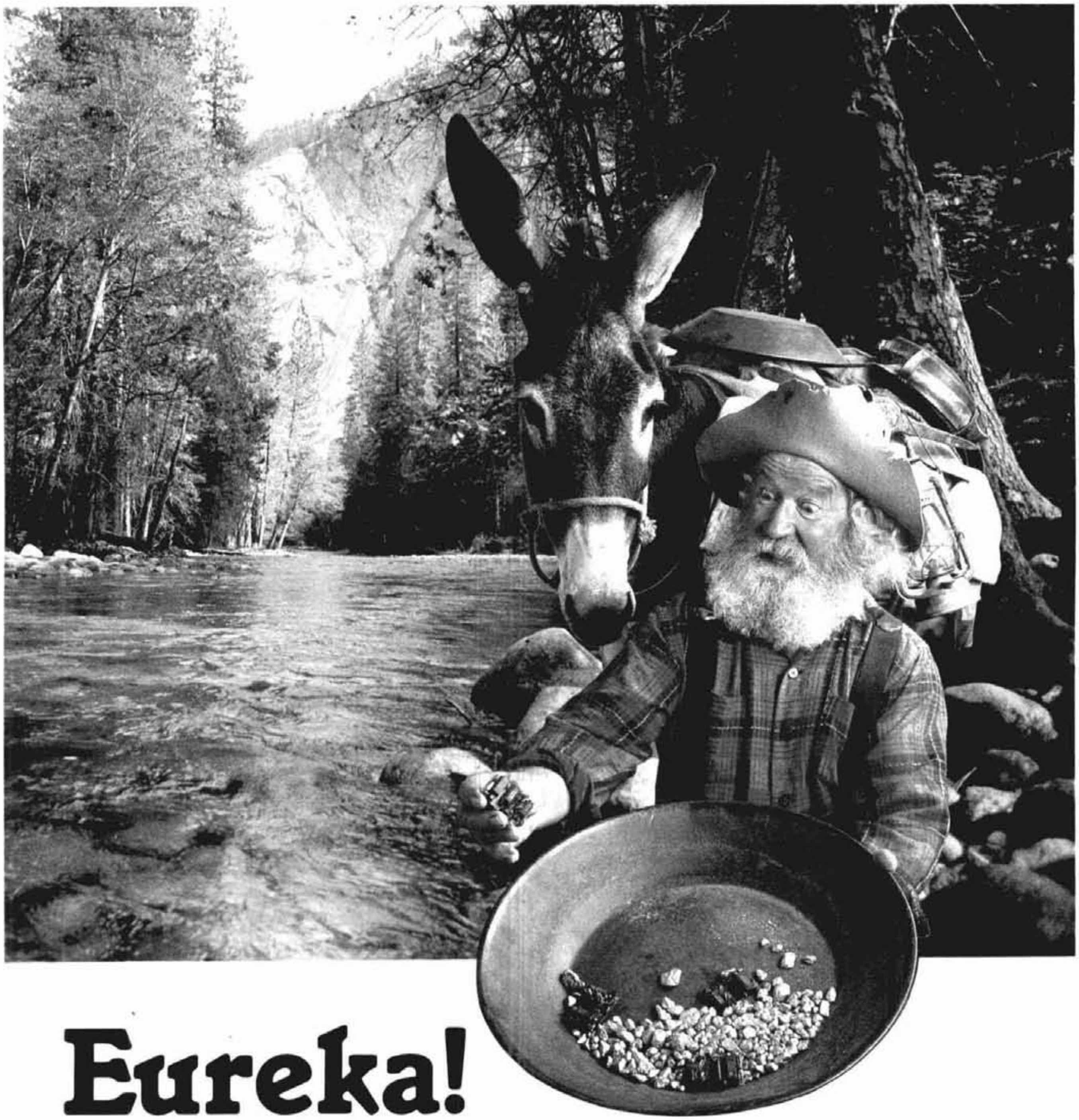

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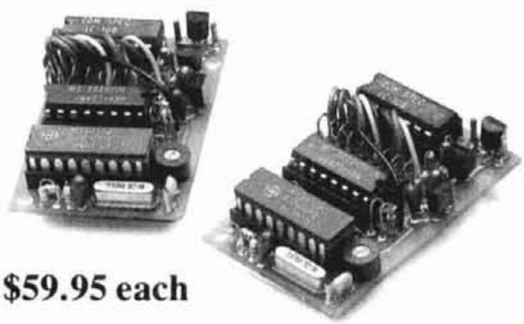

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And working the DX has never been easier with dual VFOs, single-button VFO/memory swap for split-frequency operation, eight memories, and push-button quick memory and band scan.

The 757 also lets you listen from 500 kHz to 30 MHz with its high-performance general coverage receiver. The transmitter covers 160 through 10 meters, including the new WARC bands, with 100 watts output on sideband, FM and CW.

CW buffs will enjoy the delights of full QSK operation. Plus the massive heatsink and duct-flow cooling system allow continuous RTTY operation for up to 30 minutes. Use the FP-757HD heavy-duty power supply option for continuous-duty applications.

And of course, there's the 757's highly attractive price. It's the perfect way to get all the HF performance you desire, with money left over to apply toward other ham gear. Perhaps a power supply for base station use. An antenna or antenna tuner. Or whatever else makes your operation complete.

So ask your dealer today about Yaesu's FT-757GX. The most celebrated HF price/performer on the air.

YAESU

Yaesu Electronics Corporation
6851 Walthall Way, Paramount
CA 90723 (213) 633-4007

Yaesu Cincinnati Service Center
9070 Gold Park Drive, Hamilton
OH 45011 (513) 874-3100

Prices and specifications subject to change without notice. Contact your Yaesu dealer regarding MARS operation.

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KENWOOD

...pacesetter in Amateur radio

"Digital DX-terity!"

TS-430S

Digital DX-terity—that outstanding attribute built into every Kenwood TS-430S lets you QSY from band to band, frequency to frequency and mode to mode with the speed and ease that will help you earn that dominant DX position from the shack or from the mobile!

- **Covers all Amateur bands**
  160 through 10 meters, as well as the new 30, 17, and 12 meter WARC bands. High dynamic range, general coverage receiver tunes from 150 kHz to 30 MHz. Easily modified for HF MARS operation.
- **Superb interference reduction**
  Eliminate QRM with the IF shift and tuneable notch filter. A noise blanker supresses ignition noise. Squelch, RF attenuator, and RIT are also provided. Optional IF filters may be added for optimum interference reduction.
- **Reliable, all solid state design.**
  Solid state design permits input power of 250 watts PEP on SSB, 200 watts DC on CW, 120 watts on FM (optional), or 60 watts on AM. Final amplifier protection circuits and a cooling fan are built-in.
- **Memory channels.**
  Eight memory channels store frequency, mode and band data. Channel 8 may be programmed for split-frequency operation. A front panel switch allows each memory channel to operate as an independent VFO or as a fixed frequency. A lithium battery backs up stored information.
- **Programmable, multi-function scan.**
- **Speech processor built-in.**
- **Dual digital VFOs.**
- **VOX circuit, plus semi break-in with sidetone.**

Optional accessories:
• PS-430 compact AC power supply • SP-430 external speaker • MB-430 mobile mounting bracket • AT-130 compact antenna tuner covers 80-10 meters, incl. WARC bands • AT-250 automatic antenna tuner covers 160-10 meters, incl. WARC bands • TL-922A 2 kW PEP linear amplifier • FM-430 FM unit • YK-88C (500 Hz) or YK-88CN (270 Hz) CW filters • YK-88SN (1.8 kHz) narrow SSB filter • YK-88A (6 kHz) AM filter • MC-42S UP/DOWN hand mic. • MC-60A/80/85 deluxe desk mics. • SW-2000/200A SWR/power meters • SW-100A SWR/power/volt meter • PC-1A phone patch • HS-4, HS-5, HS-6, HS-7 headphones

KENWOOD

TRIO-KENWOOD COMMUNICATIONS
1111 West Walnut Street
Compton, California 90220

Complete service manuals are available for all Trio-Kenwood transceivers and most accessories. Specifications and prices are subject to change without notice or obligation.